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Five Year Ground Exposure of Composite Materials Used on The Bell Model 206L Flight Service Evaluation

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FIVE YEAR GROUND EXPOSURE OF COMPOSITE MATERIALS USED ON THE BELL MODEL 206L FLIGHT SERVICE EVALUATION

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Introduction

During the past ten years, NASA has sponsored programs to build a data base and establish confidence in the long-term durability of advanced composite materials(reference 1). Flight service experience is being obtained on primary and secondary structural components installed on commercial aircraft and from material specimens exposed at different locations. Although commercial aircraft and helicopters may fly in the same environment the behavior of composite materials on each vehicle may differ substantially. Most of the projected usage for composites in helicopter fuselage is Kevlar-49®/epoxy with selective reinforcement of graphite/epoxy using 250°F curing epoxies. Most commercial aircraft are using 350°F cure graphite/epoxy systems with very little use of Kevlar/epoxy. Considering only the effects of moisture, materials in the minimum gage structure in most helicopter fuselage would reach equilibrium moisture content in a short time whereas the heavier gage structure on a commercial aircraft could take months to reach an equilibrium condition.

Therefore, in 1978, NASA and the U.S. Army Research and Technology activity initiated the first major program to evaluate composite helicopter components in flight service. The flight service program includes four components per aircraft. There are three secondary structural components fabricated from Kevlar-49/epoxy and one primary structural structural component fabricated from graphite/epoxy per aircraft. Concurrent with the flight program, specimens from materials used to fabricate the components are being exposed in outdoor ground racks and are being returned for testing at prescribed intervals.

This paper describes the results of tests on specimens that have been exposed for the first five years of a planned ten year ground exposure program

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Exposure Specimens

Composite material systems are being exposed on the North American Continent in areas that have varying environmental conditions. The composite systems are: 1.) Kevlar-49 fabric(style 281) /F-185 epoxy, 2.) Kevlar-49 fabric(style 120) /LRF-277 epoxy , 3.) Kevlar-49 fabric (style 281) /CE-306 epoxy , and 4.) T-300 Graphite tape/ E-788 epoxy . The F-185 epoxy is a 250°F cure system. The LRF-277 is a 250°F cure proprietary resin. The CE-306 is cured at 200°F for five hours. The E-788 is a 350°F cure epoxy. Style 281 Kevlar-49 fabric is a plain weave with 17 ends/inch of 1140 denier yarn in each direction and has a weight of 5.0 ounces per square yard. Style 120 fabric is a plain weave with 34 ends/inch of 195 denier yarn in each direction and has a weight of 1.8 ounces per square yard. The material suppliers, specimen nominal thicknesses, and fiber lay-up patterns are given in Table I.

The materials are exposed outdoors in racks (figure 1) at five locations on the North American Continent as shown in figure 2. The racks at Toronto, Canada and Hampton, VA are installed on the roofs of buildings. Racks at Cameron, LA and Ft. Greely, AK are installed on stands approximately 18 inches above the ground. The remaining rack is on a working oil platform in the Gulf of Mexico. The racks were installed in 1980 and contain five panels each for removal after 1, 3, 5, 7, and 10 years of exposure. A panel contains 24 each of tension, short-beam-shear (SBS), IITRI compression specimens and four 2.0 inch wide specimens to observe the weathering characteristics of each material system. The specimen design is shown in figure 3 and is also given in reference 2. The tension, compression and SBS specimens are painted with a polyurethane paint(IMIRON[1]) that is used on the flight service helicopters. The remaining specimens were left unpainted to determine the weathering effect on bare composites.

The specimens used for moisture determination were cut from the tested tension specimens. A 0.5 inch long section was cut from the undamaged area of the tension specimens as soon as possible after completion of testing. The paint was removed by sanding, using caution not to remove an excessive amount of the outer ply. Each specimen was weighed after the paint removal. A 0.5 inch long specimen was also removed from the unpainted exposure specimen and weighed prior to being used for moisture determination. All specimens were stored in sealed plastic bags between different operations.

Test Methods

Each panel was received at Langley Research Center sealed in a plastic bag. The panel remained in the sealed bag until testing was initiated. All tests were performed at room temperature on six replicates for each specimen type. The tests were performed in accordance with the following ASTM standards; 1.) Tension-D3039, 2.) SBS-D2344, 3.) Compression-D3410 using the IITRI test fixture.

The specimens used for moisture determination were placed in a vacuum oven at 140°F. Each specimen was weighed periodically to determine weight loss as a function of drying time.

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[1] Manufactured by Dupont Corp., Wilmington, DE

Results and Discussion

In the summer of 1985, the exposure racks (figure 1) located at Cameron, LA and on the Off Shore Oil Platform were destroyed by hurricanes. All the following data for five year exposure will be from the three remaining sites; Hampton, Virginia; Toronto, Canada; and Ft. Greely, Alaska.

Residual Compression Strength - Compression tests were conducted to determine the effect of exposure and exposure site on the residual strength. The baseline strengths for the as-fabricated ground exposure specimens are given in Table II. The actual specimen size, maximum failure load and failure stress for each specimen are given in Table II. The mean strength and standard deviation are also given for each material. The results of tests on compression specimens that have been exposed up to 5 years are tabulated in Tables III-VI. These tables include the specimen size, failure load, and failure stress for each specimen that has been tested. The mean compression strength and standard deviation for each set of replicate specimens (same exposure site and exposure time) are also given in Tables III-VI. A summary of the mean strengths and standard deviations for the baseline and exposed specimens are given in Table VII.

The residual compressive strength for each material as a function of exposure time and exposure location are presented in figures 4-7. The mean failure stress and range of failure stress are presented for each set of six replicate specimens. Also shown in each figure is the scatter in the baseline strength for each material. The residual strength is the ratio of failure stress to the mean baseline compressive strength for the material type.

Residual compressive strength for Kevlar-49/CE-306 is presented in figure 4. The baseline scatter for this material is 5 percent(-2 percent to +3 percent). The minimum mean residual compressive strength was 93 percent for specimens exposed for 5 years at Toronto, Canada. Residual mean strength of specimens exposed at Hampton, VA and in the Gulf of Mexico equalled or exceeded the minimum baseline strength of 98 percent. Residual compressive strength for Kevlar-49/F-185 is presented in figure 5. The baseline scatter for this material is 5 percent(-1 percent to 4 percent). The minimum mean residual compression strength was 90 percent for specimens exposed one year at Ft. Greely, AK. Residual strength of specimens from Cameron, LA, Gulf of Mexico, and Hampton, VA all equalled or exceeded the minimum baseline scatter band of 97 percent. Residual compressive strength for Kevlar-49/LRF-277 is presented in figure 6. The baseline scatter for this material is 11 percent(-4 percent to +7 percent). The minimum mean residual compression strength was 84 percent for specimens exposed for one year at Ft. Greely, AK. The residual strengths for all exposure sites are below the minimum baseline scatter band. A general observation that can be made for all Kevlar-49/epoxy materials is that all residual strengths for specimens from Toronto, Canada and Ft. Greely, AK are below the minimum baseline scatter indicating a possible effect from the cold climate. Residual compression strength for T300/E-788 graphite/epoxy is presented in figure 7. The baseline scatter is 7 percent(-4 percent to +3 percent). The minimum mean residual compressive strength was 91 percent for specimens exposed for 3 years at Cameron, LA. All of the mean residual strength averages are within 3 percent of the baseline scatter band.

The effect of exposure location on the residual compression strength of each material is presented in figures 8-11. The data points represent a comparison of the mean compression strength at each exposure site with the mean baseline compression strength value for that material system. Each data point is the average of six tests. The Kevlar-49/LRF-277 material (figure 9) has lower compression strength retention than the other materials. The Kevlar-49/LRF-277 varies from 84 to 94 percent after one year of exposure, 84 to 91 percent after three years of exposure, and 87 to 95 percent after five years of exposure. The other material systems (figs. 8,10,11) exceeded 90 percent after one year of exposure, 93 percent after three years and five years of exposure.

The data points shown in figure 12 represent a comparison of the mean baseline compression strength with the mean compression strength data of specimens exposed at the five different locations shown in Fig. 2. Also shown in figure 12 is the scatter band in the baseline strength for all materials tested. Each point shown for 1 or 3 years of exposure is the average of thirty tests(5 racks and 6 replicates of each material) while points at 5 years of exposure are the average of eighteen tests(3 racks and 6 replicates of each material). The residual compression strengths of exposed painted specimens shown in figure 12 vary between 88 and 101 percent of the average baseline strength. The T-300/E-788 graphite is at the upper bound and varies between 98 and 101 percent of the average baseline strength. Kevlar-49/LRF-277 material is at the lower bound and varies between 88 and 90 percent of the average baseline strength. Residual compression strengths for all materials except Kevlar-49/LRF-277 fall within the baseline scatter band.

Residual Short-Beam Shear Strength - Short-beam-shear(SBS) tests were conducted to determine degradation of the fiber-to-matrix bond as a function outdoor exposure time and exposure site. Generally interlaminar failures occured at the mid-plane of the specimens. The baseline strengths for the as-fabricated ground exposure specimens are given in Table VIII. The actual specimen size, maximum failure load and failure stress for each baseline specimen are given in Table VIII. The mean strength and standard deviation are also given for each material. The results of tests on SBS specimens that have been exposed up to 5 years are tabulated in Tables IX-XII. These tables include the specimen size, failure load, and failure stress for each specimen that has been tested. The mean SBS strength and standard deviation for each set of replicate specimens (same exposure site and exposure time) are also given in Tables IX-XII. A summary of the mean strengths and standard deviations for the baseline and exposed specimens are given in Table XIII.

The residual SBS strength for each material as a function of exposure time and exposure location are presented in figures 13-16. The mean failure stress and range of failure stress are presented for each set of six replicate specimens. Also shown in each figure is the scatter in the baseline strength for each material. The residual strength is the ratio of failure stress to the mean baseline SBS strength for the material type.

Residual SBS strength for Kevlar-49/CE-306 is presented in figure 13. The baseline scatter for this material is 11 percent(-7 percent to +4 percent). The minimum mean residual SBS strength was 93 percent for specimens exposed for 1 year at Ft. Greely, AK and 3 years at Cameron, LA. The mean residual SBS strength for all other exposure sites and exposure times exceeded the baseline minimum of 93 percent. Residual SBS strength for Kevlar-49/F-185 is presented in figure 14. The baseline scatter for this material is 10 percent ($\pm$ 5 percent). The minimum mean SBS strength was 85 percent for specimens exposed for one year at Ft. Greely, AK. The mean residual SBS strength for all other exposure sites and exposure times exceeded the baseline minimum of 95 percent. Residual SBS strength for Kevlar-49/LRF-277 is presented in figure 15. The baseline scatter for this material is 9 percent(-5 percent to +4 percent). The minimum mean SBS strength was 87 percent for specimens exposed for one year at Cameron, LA and five years at Ft. Greely, AK. Eight of the eleven remaining data points are between 87 percent and 95 percent, the baseline minimum. The Kevlar-49/LRF-277 exhibited poor SBS strength retention when compared to the other two Kevlar-epoxy systems. Residual SBS strength for T300/E-788 graphite/epoxy is presented in figure 16. The baseline scatter for this material is 7 percent (-4 percent to +3 percent). The minimum mean SBS strength was 96 percent, the baseline minimum, for specimens exposed for five years at Ft. Greely, AK. Specimens exposed at sites other than Ft. Greely exceeded 100 percent strength retention after exposure.

Effects of different environments on the residual SBS strength for each material is shown in figure 17-20. The data points represent a comparison of the average SBS strength at each exposure site with the average baseline SBS strength for that material system. The Kevlar-49/LRF-277 has lower SBS strength retention than the other materials. The strength retention of Kevlar-49/LRF-277 (figure 18) varies from 87 to 97 percent after one year of exposure, 87 to 95 percent after three years of exposure, and 87 to 96 percent after five years of exposure. The other material systems (figures 17,19,20) strength retention exceed 92 percent after one year of exposure, 93 percent after three years of exposure, and 91 percent after five years of exposure.

Residual SBS strengths of painted specimens with up to five years of exposure are shown in figure 21. The data points represent a comparison of the average baseline SBS strength with the average SBS strength data of specimens exposed at five different locations shown in figure 2. Each point shown for 1 or 3 years of exposure is the average of thirty tests(5 racks and 6 replicates of each material) while points at 5 years of exposure are the average of eighteen tests(3 racks and 6 replicates of each material). The SBS strengths vary between 91 and 103 percent of baseline strength. Like the compression strength, the T-300/E-788 SBS strength is at the upper bound, between 100 and 103 percent of the average baseline strength, while the Kevlar-49/LRF-277 is at the lower bound between 91 and 92 percent of the average baseline strength. Residual short beam shear strengths for all materials except Kevlar-49/LRF-277 fall within the baseline scatter band.

Residual Tension Strength - Tension tests were conducted to determine the effect of environmental exposure and exposure site on the residual strength. The baseline strengths for the as-fabricated ground exposure specimens are given in Table XIV. The actual specimen size, maximum failure load and failure stress for each specimen are given in Table XIV. The mean strength and standard deviation are also given for each material. The results of tests on tension specimens that have been exposed up to 5 years are tabulated in Tables XV-XVIII. These tables include the specimen size, failure load, and failure stress for each specimen that has been tested. The mean tension strength and standard deviation for each set of replicate specimens (same exposure site and exposure time) are also given in Tables XV-XVIII. A summary of the mean strengths and standard deviations for the baseline and exposed specimens are given in Table XIX.

The residual tensile strength for each material as a function of exposure time and exposure location are presented in figures 22-25. The mean failure stress and range of failure stress are presented for each set of six replicate specimens. Also shown in each figure is the scatter in the baseline strength for each material. The residual strength is the ratio of failure stress to the average baseline compressive strength for the material type.

Residual tension strength for Kevlar-49/CE-306 is presented in figure 22. The baseline scatter for this material is 11 percent(-6 percent to +5 percent). The minimum mean residual tension strength was 99 percent for specimens exposed for 3 years at Cameron, LA. The mean residual tension strength for all other exposure sites and exposure times exceeded 100 percent of baseline mean. Residual tension strength for Kevlar-49/F-185 is presented in figure 23. The baseline scatter for this material is 11 percent (-3 percent to +8 percent). The mean tension strength for all exposure sites exceeded 100 percent of the baseline mean strength. Residual tension strength for Kevlar-49/LRF-277 is presented in figure 24. The baseline scatter for this material is 7 percent(-4 percent to +3 percent). The minimum mean SBS strength was 99 percent for specimens exposed for one year in the Gulf of Mexico. All other exposure sites exceeded 100 percent of the baseline mean strength. Residual tension strength for T300/E-788 graphite/epoxy is presented in figure 25. The baseline scatter for this material is 8 percent ($\pm$4 percent). The minimum mean tension strength was 97 percent for specimens exposed for one year at Cameron, LA and in the Gulf of Mexico. All other specimen exposures, except after five years exposure at Toronto, Canada, exceeded 100 percent of baseline mean strength.

Effects of different environments on the residual tension strength for each material is shown in figures 26-29. The data points represent a comparison of the average tension strength at each exposure site with the average baseline tension strength for that material system. All data points are above the baseline minimum strength. The minimum value for all exposures is 97 percent for one year exposure of T-300/E-788 at Cameron, LA. Most of the remaining points exceed 100 percent of baseline mean strength.

The data points shown in figure 30 represent a comparison of the average baseline tension strength with the average tension strength data of specimens exposed at the five different locations shown in Fig. 2. Also shown in figure 30 is the scatter band in the baseline strength for all materials tested. Each point shown for 1 or 3 years of exposure is the average of thirty tests(5 racks and 6 replicates of each material) while points at 5 years of exposure are the average of eighteen tests(3 racks and 6 replicates of each material). The average of all specimens exceed 100 percent of the baseline mean strength.

Moisture Absorption - Temperature, relative humidity, exposure conditions, type of fiber and matrix determine the amount of moisture that a composite material will absorb. The object of these tests is to determine the moisture absorption of composite materials when exposed to various outdoor realtime environments. A summary of moisture absorption as a fraction of composite specimen weight for painted specimens that were exposed for three and five years are tabulated in Table XX and shown in figures 31-34. Each data point for the painted specimens is the average of six replicates. Kevlar-49/epoxy materials absorb four to five times more moisture than graphite/epoxy because the Kevlar fibers absorb moisture. All materials show an increase in moisture absorption from the third to fifth years. The average values, for each material, shown in Table XX compare well with published values for other Kevlar/epoxy and graphite/epoxy systems (reference 1). A summary of the weight loss for the unpainted specimens is given in Table XXI and shown in figures 31-34. Each data point for the unpainted specimens is from a single specimen. All values in Table XXI appear reasonable except for the 0.74 percent weight loss for the T-300/E-788 material exposed in the Gulf of Mexico. Since there is only one specimen available it is not possible to determine if this is a valid data point. Comparing the average weight loss shown in Table XX and XXI indicates the Kevlar-49/F-185 (figure 32) retains approximately 0.6 percent more moisture when painted. The Kevlar-49/LRF-277(figure 33) material retains 0.1 to 0.3 percent less moisture when painted. Paint has little effect on moisture absorption of Kevlar-49/CE-306(figure 31) and T-300/E-788(figure 34) after three years of exposure. After five years of exposure the Kevlar-49/CE-306 and T-300/E-788 retains 0.15 to 0.4 percent more moisture when painted.

Weathering - Effects of weathering on the bare composites that were exposed at Hampton, VA are shown in figures 35-38. Each figure shows the as-fabricated, one year, three year and five year specimens exposed at Hampton, VA. The photographs shown in these figures is a 15X magnification of the exposed surface. Figure 35 indicates the surfaces of Kevlar-49/CE-306 after exposure. The photograph of the specimen after one year of exposure indicates some resin has been washed away by the reduced definition of the pattern of the peel ply used in fabrication. Additional resin is lost on the high spots of the warp fibers after 3 years of exposure as can be seen in the photograph(figure 35). Some resin still exists in the low areas around the fill fibers. After five years of exposure very little resin remains on the surface. The as-fabricated and one year exposure views in figure 36 for Kevlar-49/F-185 material indicate the surface fibers are coated with epoxy. The three year exposure view has the surface fibers exposed due to ultraviolet degradation of the surface layer of epoxy. After five years of exposure of the Kevlar-49/F-185 material all resin has disappeared and it appears some of the fiber on the humps in the fill yarns has also disappeared. The as-fabricated views of Kevlar-49/LRF-277 material in figure 37 indicate most of the surface fibers are coated with epoxy. The one year exposure view(figure 37) indicates most of the surface resin is missing. All the resin is missing and some fiber damage is indicated in the three year exposure view shown in figure 37. After five years of exposure only fiber fragments remain of the outer ply and the resin shown is from between the plies. The T-300/E-788 Graphite/epoxy exposed for three and five years, shown in figure 38, has bare surface fibers. Some resin loss is indicated after one year of exposure. The specimens exposed at the other locations had similar resin loss. This emphasizes the need to keep composites protected from ultraviolet exposure.

Concluding Remarks

Results after five years of ground exposure indicates that all material systems exhibit good strength retention in compression and short beam shear. All material systems exceeded 85 percent strength retention after one and three years of exposure and 87 percent after five years of exposure, independent of exposure site. Residual tensile strength of all materials did not show a significant reduction.

The Kevlar-49/F-185 material absorbs approximately 0.6 percent more moisture when painted. Kevlar-49/LRF-277 material absorbs approximately 0.3 percent less moisture when painted. Paint has little effect on moisture absorption of Kevlar-49/CE-306 and T-300/E-788 after three years of exposure. All materials show an increase in moisture absorption from the third to the fifth years of outdoor exposure.

The exposure of unpainted specimens demonstrate the need to protect composites from ultraviolet exposure.

REFERENCES

1. Dexter, H.Benson and Baker,Donald J., "Worldwide flight and Ground-Based Exposure of Composite Materials," NASA CP-2321, August 1984,p.17-49.

2. Zinberg,Herbert,"Flight Service Evaluation of Composite Components on the Bell Model 206L: Design, Fabrication and Testing," NASA CR-166002, November 1982.

TABLE I.- DESCRIPTION OF EXPOSURE SPECIMENS

Material type	Material supplier	Nominal specimen thickness, in.			Fiber lay-up pattern*
		Short-beam shear	Compression	Tension	
K-49/CE-306 Kevlar-49/ epoxy	Ferro Corp.	.070	.070	.070	[0] fabric
K-49/F-185 Kevlar-49/ epoxy	Hexcel Corp.	.080	.080	.080	$[0/45/0]_s$ fabric
K-49/LRF-277 Kevlar/ epoxy	Brunswick Corp.	.070	.070	.070	[0] fabric
T-300/E-788 Graphite/ epoxy	U.S. Polymeric Co.	.072	.072	.072	$[0/45/-45/0]_{2s}$ tape

* The 0 degree fiber direction is oriented along the length of the test specimen

TABLE II. - BASELINE COMPRESSION STRENGTH OF COMPOSITE MATERIALS

Material type	Specimen number	Width in.	Thickness in.	Maximum load lbf.	Failure stress psi
K-49/CE-306 Kevlar/epoxy	313F	.2616	.0986	463.	17950.
	314F	.2667	.1002	481.	17999.
	315F	.2606	.0974	476.	18753.
	316F	.2613	.0971	472.	18603.
	317F	.2570	.0987	460.	18135.
	318F	.2541	.0985	453.	18099.
				Mean =	18257.
				S.D. =	337.
K-49/F-185 Kevlar/epoxy	317	.2594	.1013	525.	19979.
	318	.2602	.1000	510.	19600.
	319	.2693	.0948	510.	19977.
	320	.2581	.0987	509.	19981.
	321	.2549	.0965	515.	20937.
	322	.2460	.1017	515.	20585.
				Mean =	20176.
				S.D. =	489.
K-49/LRF-277 Kevlar/epoxy	326B	.2453	.0790	416.	21467.
	327B	.2311	.0772	425.	23822.
	328B	.2403	.0772	420.	22640.
	329B	.2364	.0783	402.	21718.
	330B	.2295	.0776	407.	22853.
	331B	.2450	.0772	410.	21677.
				Mean =	22363.
				S.D. =	909.
T300/E-788 Graphite/ epoxy	158V	.2553	.0716	2210.	120901.
	159V	.2573	.0714	2315.	126012.
	160V	.2526	.0684	2240.	129646.
	161V	.2562	.0669	2215.	129232.
	162V	.2556	.0693	2305.	130130.
	163V	.2552	.0701	2185.	122139.
				Mean =	126343.
				S.D. =	4025.

S.D. = Standard Deviation

TABLE III. - COMPRESSION STRENGTH OF PAINTED Kevlar-49/CE-306
AFTER ENVIRONMENTAL EXPOSURE

(a) exposed at Cameron, LA

Specimen Number	Exposure Time,yr	Width in.	Thickness in.	Load lbf.	Failure Stress,psi
319F	1	.2606	.0988	456.	17711.
320F	1	.2660	.0985	462.	17633.
321F	1	.2629	.0988	465.	17902.
322F	1	.2551	.0965	472.	19174.
323F	1	.2572	.1012	472.	18134.
324F	1	.2616	.1008	443.	16800.
				Mean =	17892.
				S.D =	774.
325F	3	.2544	.0993	405.	16032.
326F	3	.2602	.1017	448.	16930.
327F	3	.2602	.0973	463.	18288.
328F	3	.2621	.0988	500.	19308.
329F	3	.2563	.0973	410.	16441.
330F	3	.2586	.0990	459.	17929.
				Mean =	17488.
				S.D =	1239.

(b.) exposed in the Gulf of Mexico

Specimen Number	Exposure Time,yr	Width in.	Thickness in.	Load lbf.	Failure Stress,psi
349F	1	.2672	.0962	464.	18051.
350F	1	.2553	.0901	429.	18650.
351F	1	.2667	.0967	462.	17914.
352F	1	.2665	.0973	454.	17508.
353F	1	.2575	.0996	447.	17429.
354F	1	.2578	.0998	446.	17335.
				Mean =	17815.
				S.D. =	497.
355F	3	.2489	.0998	404.	16264.
356F	3	.2489	.1005	438.	17510.
357F	3	.2551	.0997	476.	18715.
358F	3	.2526	.0989	459.	18373.
359F	3	.2532	.1005	470.	18470.
360F	3	.2627	.0947	434.	17445.
				Mean =	17796.
				S.D =	915.

S.D. = Standard deviation

TABLE III.- CONTINUED

(c) exposed at Hampton, VA

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
379F	1	.2532	.0980	515.	20755.
380F	1	.2565	.0973	482.	19313.
381F	1	.2573	.0956	471.	19148.
382F	1	.2650	.0953	462.	18294.
383F	1	.2523	.0972	463.	18880.
384F	1	.2574	.0987	468.	18421.
				Mean =	19135.
				S.D. =	887.
385F	3	.2560	.0916	475.	20256.
386F	3	.2657	.0978	480.	18472.
387F	3	.2656	.0950	483.	19142.
388F	3	.2546	.0993	480.	18986.
389F	3	.2662	.0950	474.	18743.
400F	3	.2624	.0964	473.	18699.
				Mean =	19050.
				S.D. =	635.
401F	5	.2665	.0972	461.	17797.
402F	5	.2548	.0966	438.	17795.
403F	5	.2629	.0834	412.	18791.
404F	5	.2649	.0957	459.	18106.
405F	5	.2632	.1007	448.	16903.
406F	5	.2535	.0962	454.	18617.
				Mean =	18001.
				S.D.	679.

TABLE III. - CONTINUED

(d.) exposed at Toronto, Ontario, Canada

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
419F	1	.2515	.0962	439.	18145.
420F	1	.2446	.0862	379.	17975.
421F	1	.2585	.1008	447.	17155.
422F	1	.2586	.1002	415.	16016.
423F	1	.2521	.0893	423.	18790.
424F	1	.2409	.0963	404.	17415.
				Mean =	17583.
				S.D. =	958.
425F	3	.2564	.0980	410.	16317.
426F	3	.2625	.1009	424.	16008.
427F	3	.2639	.0968	436.	17068.
428F	3	.2539	.0950	438.	18159.
429F	3	.2664	.0960	421.	16462.
430F	3	.2658	.0955	457.	18004.
				Mean =	17003.
				S.D. =	905.
431F	5	.2583	.0963	449.	18051.
432F	5	.2541	.1002	469.	18420.
433F	5	.2577	.0942	430.	17713.
434F	5	.2552	.0983	467.	18616.
435F	5	.2617	.0955	429.	17165.
436F	5	.2577	.0980	454.	17977.
				Mean =	17990.
				S.D. =	517.

TABLE III. - CONCLUDED

(e) exposed at Ft. Greely,AK

Specimen Number	Exposure Time,yr	Width in.	Thickness in.	Load lbf.	Failure Stress,psi
394F	1	.2535	.0953	441.	18254.
395F	1	.2521	.0908	407.	17780.
396F	1	.2635	.1008	424.	15963.
397F	1	.2585	.0928	386.	16091.
398F	1	.2652	.0971	444.	17242.
399F	1	.0963	.2544	435.	17756.
				Mean =	17181.
				S.D. =	950.
467F	3	.2648	.1006	472.	17718.
468F	3	.2646	.0964	427.	16740.
390F	3	.2590	.0993	463.	18002.
391F	3	.2527	.0971	440.	17932.
392F	3	.2645	.0883	420.	17983.
393F	3	.2610	.1000	439.	16820.
				Mean =	17533.
				S.D. =	592.
461F	5	.2548	.0972	431.	17402.
462F	5	.2680	.0934	455.	18177.
463F	5	.2638	.0976	433.	16818.
464F	5	.2630	.0963	474.	18715.
465F	5	.2507	.0954	385.	16097.
466F	5	.2660	.0953	458.	18067.
				Mean =	17546.
				S.D. =	968.

TABLE IV - COMPRESSION STRENGTH OF PAINTED Kevlar-49/F-185
AFTER ENVIRONMENTAL EXPOSURE

(a) exposed at Cameron, LA

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
323	1	.2566	.0944	503.	20765.
324	1	.2615	.0971	507.	19967.
325	1	.2481	.0963	510.	21346.
326	1	.2559	.0966	492.	19903.
327	1	.2585	.0909	480.	20428.
328	1	.2573	.1001	522.	20267.
				Mean =	20446.
				S.D. =	542.
329	3	.2548	.1011	491.	19060.
330	3	.2580	.0980	492.	19459.
331	3	.2528	.0967	454.	18572.
332	3	.2503	.0980	466.	18998.
333	3	.2582	.0949	487.	19875.
334	3	.2458	.0930	458.	20036.
				Mean =	19333.
				S.D. =	560.

(b.) exposed in the Gulf of Mexico

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
353	1	.2478	.0988	506.	20668.
354	1	.2535	.0975	485.	19623.
355	1	.2491	.0970	491.	20321.
356	1	.2517	.0992	502.	20105.
357	1	.2530	.0976	482.	19520.
358	1	.2536	.0994	490.	19438.
				Mean =	19946.
				S.D. =	496.
359	3	.2593	.0974	510.	20193.
360	3	.2505	.0924	465.	20090.
361	3	.2559	.0949	490.	20177.
362	3	.2452	.0968	491.	20686.
363	3	.2468	.0941	472.	20324.
364	3	.2492	.0950	489.	20656.
				Mean =	20354.
				S.D. =	257.

S.D. = Standard deviation

TABLE IV. - CONTINUED

(c) exposed at Hampton, VA

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
383	1	.2494	.0993	490.	19786.
384	1	.2553	.0992	492.	19427.
385	1	.2521	.1008	478.	18810.
386	1	.2456	.0961	468.	19829.
387	1	.2589	.1003	507.	19524.
388	1	.2560	.0920	484.	20550.
				Mean =	19654.
				S.D. =	571.
389	3	.2543	.1005	508.	19877.
390	3	.2538	.0938	479.	20121.
391	3	.2409	.0961	495.	21382.
392	3	.2425	.1019	505.	20436.
393	3	.2514	.0996	503.	20088.
394	3	.2463	.0974	495.	20634.
				Mean =	20423.
				S.D. =	541.
395	5	.2512	.1008	502.	19825.
396	5	.2429	.1015	499.	20240.
397	5	.2393	.0976	464.	19867.
398	5	.2510	.1000	482.	19203.
399	5	.2523	.0969	484.	19797.
400	5	.2541	.1014	495.	19212.
				Mean =	19691.
				S.D. =	407.

TABLE IV. - CONTINUED

(d) exposed at Toronto, Canada

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
413	1	.2563	.0999	477.	18630.
414	1	.2673	.0958	500.	19526.
415	1	.2429	.0945	454.	19779.
416	1	.2524	.1020	482.	18722.
417	1	.2563	.1013	503.	19374.
418	1	.2530	.1005	493.	19389.
				Mean =	19236.
				S.D. =	459.
419	3	.2539	.1001	483.	19004.
420	3	.2507	.1009	495.	19569.
421	3	.2489	.1015	492.	19475.
422	3	.2569	.0969	467.	18760.
423	3	.2597	.1006	500.	19138.
424	3	.2454	.0993	485.	19903.
				Mean =	19308.
				S.D. =	417.
425	5	.2437	.0978	482.	20223.
426	5	.2580	.0934	461.	19131.
427	5	.2576	.0961	463.	18703.
428	5	.2527	.0935	471.	19934.
429	5	.2499	.1000	487.	19488.
430	5	.2601	.0981	486.	19047.
				Mean =	19421.
				S.D. =	575.

TABLE IV. - CONCLUDED

(e) exposed at Ft. Greely,AK

Specimen Number	Exposure Time,yr	Width in.	Thickness in.	Load lbf.	Failure Stress,psi
467	1	.2476	.1000	460.	18578.
468	1	.2551	.1015	458.	17688.
469	1	.2445	.1012	453.	18308.
470	1	.2600	.0979	456.	17915.
471	1	.2511	.0987	448.	18076.
472	1	.2543	.1006	467.	18255.
				Mean =	18137.
				S.D. =	314.
461	3	.2534	.1010	463.	18091.
462	3	.2616	.0939	461.	18767.
463	3	.2528	.1013	486.	18978.
464	3	.2611	.0953	481.	19331.
465	3	.2488	.0950	453.	19166.
466	3	.2487	.0943	447.	19060.
				Mean =	18899.
				S.D. =	438.
455	5	.2542	.0942	454.	18960.
456	5	.2471	.0945	436.	18672.
457	5	.2585	.0995	470.	18273.
458	5	.2451	.0988	455.	18789.
459	5	.2481	.0991	452.	18384.
460	5	.2563	.0969	477.	19206.
				Mean =	18714.
				S.D. =	350.

TABLE V. - COMPRESSION STRENGTH OF PAINTED KEVLAR-49/LRF-277
AFTER ENVIRONMENTAL EXPOSURE

(a) exposed at Cameron, LA

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
332B	1	.2387	.0783	370.	19796.
333B	1	.2539	.0773	423.	21553.
334B	1	.2229	.0788	382.	21748.
335B	1	.2294	.0779	395.	22104.
336B	1	.2510	.0785	397.	20149.
337B	1	.2558	.0759	407.	20963.
				Mean =	21052.
				S.D. =	921.
338B	3	.2512	.0777	368.	18854.
339B	3	.2364	.0778	361.	19628.
340B	3	.2539	.0814	376.	18193.
341B	3	.2194	.0789	355.	20508.
342B	3	.2513	.0781	393.	20024.
343B	3	.2353	.0778	355.	19392.
				Mean =	19433.
				S.D. =	827.

(b.) exposed in the Gulf of Mexico

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
362B	1	.2263	.0769	359.	20629.
363B	1	.2300	.0777	372.	20816.
364B	1	.2438	.0788	396.	20613.
365B	1	.2365	.0774	366.	19994.
366B	1	.2326	.0787	382.	20868.
367B	1	.2288	.0767	385.	21939.
				Mean =	20810.
				S.D. =	635.
368B	3	.2480	.0796	404.	20465.
369B	3	.2430	.0797	352.	18175.
370B	3	.2248	.0790	370.	20834.
371B	3	.2398	.0773	334.	18018.
372B	3	.2227	.0782	317.	18203.
373B	3	.2319	.0786	349.	19147.
				Mean =	19140.
				S.D. =	1241.

TABLE V. - CONTINUED.

(c) exposed at Hampton, VA

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
392B	1	.2517	.0769	412.	21286.
393B	1	.2375	.0789	380.	20279.
394B	1	.2551	.0785	360.	17977.
395B	1	.2524	.0799	404.	20033.
396B	1	.2317	.0793	364.	19811.
397B	1	.2445	.0783	386.	20163.
				Mean =	19925.
				S.D. =	1082.
398B	3	.2393	.0785	403.	21453.
399B	3	.2461	.0788	376.	19389.
400B	3	.2509	.0837	373.	17762.
401B	3	.2386	.0810	407.	21059.
402B	3	.2683	.0781	402.	19185.
403B	3	.2266	.0761	370.	21456.
				Mean =	20051.
				S.D. =	1509.
404B	5	.2449	.0793	394.	20288.
405B	5	.2253	.0779	349.	19885.
406B	5	.2483	.0797	375.	18949.
407B	5	.2237	.0771	343.	19887.
408B	5	.2245	.0778	321.	18378.
409B	5	.2377	.0778	347.	18764.
				Mean =	19359.
				S.D. =	762.

TABLE V. - CONTINUED

(d) exposed at Toronto, Canada

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
422B	1	.2429	.0798	397.	20481.
423B	1	.2243	.0772	345.	19924.
424B	1	.2226	.0772	352.	20483.
425B	1	.2410	.0787	364.	19192.
426B	1	.2200	.0790	346.	19908.
427B	1	.2355	.0802	368.	19484.
				Mean =	19912.
				S.D. =	520.
428B	3	.2578	.0799	362.	17574.
429B	3	.2498	.0773	372.	19265.
430B	3	.2508	.0775	384.	19756.
431B	3	.2490	.0779	368.	18972.
432B	3	.2366	.0774	346.	18894.
433B	3	.2276	.0788	343.	19125.
				Mean =	18931.
				S.D. =	731.
434B	5	.2526	.0768	415.	21392.
435B	5	.2498	.0780	412.	21145.
436B	5	.2407	.0795	403.	21060.
437B	5	.2510	.0800	440.	21912.
438B	5	.2377	.0816	401.	20674.
439B	5	.2385	.0787	387.	20618.
				Mean =	21134.
				S.D. =	481.

TABLE V. - CONCLUDED

(e) exposed at Ft. Greely,AK

Specimen Number	Exposure Time,yr	Width in.	Thickness in.	Load lbf.	Failure Stress,psi
476B	1	.2317	.0772	337.	18840.
477B	1	.2581	.0767	362.	18286.
478B	1	.2360	.0786	357.	19246.
479B	1	.2529	.0799	374.	18509.
480B	1	.2526	.0812	385.	18770.
481B	1	.2414	.0770	366.	19690.
				Mean =	18890.
				S.D. =	509.
470B	3	.2531	.0792	391.	19506.
471B	3	.2363	.0770	373.	20500.
472B	3	.2339	.0759	360.	20278.
473B	3	.2206	.0790	361.	20715.
474B	3	.2375	.0777	384.	20809.
475B	3	.2279	.0769	366.	20884.
				Mean =	20449.
				S.D. =	512.
464B	5	.2298	.0810	360.	19340.
465B	5	.2527	.0785	349.	17593.
466B	5	.2218	.0767	360.	21161.
467B	5	.2283	.0778	361.	20325.
468B	5	.2469	.0788	376.	19326.
469B	5	.2374	.0792	382.	20317.
				Mean =	19677.
				S.D. =	1234.

TABLE VI. - COMPRESSION STRENGTH OF T-300/E-788 GRAPHITE/EPOXY AFTER ENVIRONMENTAL EXPOSURE

(a) exposed at Cameron, LA

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
164V	1	.2558	.0712	2320.	127382.
165V	1	.2550	.0706	2500.	138866.
166V	1	.2567	.0709	2375.	130494.
167V	1	.2562	.0708	2485.	136998.
168V	1	.2562	.0676	2205.	127316.
169V	1	.2555	.0689	2140.	121564.
				Mean =	130437.
				S.D. =	6510.
170V	3	.2575	.0700	1910.	105964.
171V	3	.2568	.0692	1970.	110858.
172V	3	.2562	.0690	1980.	112005.
173V	3	.2584	.0714	1960.	106234.
174V	3	.2569	.0686	2280.	129374.
175V	3	.2552	.0691	2225.	126174.
				Mean =	115102.
				S.D. =	10159.

(b.) exposed in the Gulf of Mexico

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
194V	1	.2564	.0660	2250.	132960.
195V	1	.2555	.0719	2180.	118669.
196V	1	.2552	.0708	2245.	124252.
197V	1	.2460	.0688	2365.	139736.
198V	1	.2440	.0690	2205.	130969.
199V	1	.2543	.0708	2055.	114139.
				Mean =	126787.
				S.D. =	9546.
200V	3	.2578	.0668	2085.	121073.
201V	3	.2558	.0715	2345.	128214.
202V	3	.2559	.0687	2170.	123433.
203V	3	.2560	.0714	2140.	117078.
204V	3	.2557	.0690	1950.	110524.
205V	3	.2445	.0650	1685.	106025.
				Mean =	117724.
				S.D. =	8282.

TABLE VI. - CONTINUED

(c) exposed at Hampton, VA

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
224V	1	.2568	.0692	2470.	138994.
225V	1	.2607	.0690	2290.	127305.
226V	1	.2560	.0703	2285.	126967.
227V	1	.2556	.0714	2270.	124385.
228V	1	.2570	.0718	2250.	121934.
229V	1	.2559	.0680	2230.	128152.
				MEAN =	127956.
				S.D. =	5870.
230V	3	.2559	.0693	2195.	123774.
231V	3	.2551	.0714	2350.	129021.
232V	3	.2552	.0688	2225.	126725.
233V	3	.2557	.0692	2085.	117834.
234V	3	.2549	.0692	2240.	126991.
235V	3	.2548	.0706	2375.	132026.
				Mean =	126062.
				S.D. =	4870.
236V	5	.2566	.0715	2215.	120729.
237V	5	.2582	.0712	2300.	125110.
238V	5	.2569	.0710	2345.	128564.
239V	5	.2552	.0716	2130.	116570.
240V	5	.2543	.0713	2190.	120784.
241V	5	.2555	.0685	2440.	139415.
				Mean =	125195.
				S.D. =	8091.

TABLE VI. - CONTINUED

(d) exposed at Toronto, Canada

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
254V	1	.2549	.0717	2340.	128034.
255V	1	.2563	.0683	2305.	131674.
256V	1	.2550	.0693	2275.	128738.
257V	1	.2562	.0672	2140.	124298.
258V	1	.2555	.0716	2360.	129005.
259V	1	.2559	.0709	2215.	122084.
				Mean =	127306.
				S.D. =	3489.
260V	3	.2549	.0714	2085.	114561.
261V	3	.2498	.0678	2095.	123698.
262V	3	.2553	.0680	2030.	116933.
263V	3	.2538	.0705	2385.	133293.
264V	3	.2557	.0715	2375.	129905.
265V	3	.2569	.0689	2215.	125138.
				Mean =	123921.
				S.D. =	7234.
266V	5	.2554	.0719	2180.	118715.
267V	5	.2565	.0708	2290.	126100.
268V	5	.2515	.0696	2220.	126825.
269V	5	.2564	.0716	2460.	134000.
270V	5	.2565	.0710	2390.	131236.
271V	5	.2549	.0709	2300.	127266.
				Mean =	127357.
				S.D. =	5210.

TABLE VI. - CONCLUDED

(e) exposed at Ft. Greely,AK

Specimen Number	Exposure Time,yr	Width in.	Thickness in.	Load lbf.	Failure Stress,psi
308V	1	.2558	.0713	2340.	128300.
309V	1	.2563	.0688	2090.	118525.
310V	1	.2549	.0689	2270.	129252.
311V	1	.2553	.0711	2095.	115415.
312V	1	.2553	.0695	2010.	113282.
313V	1	.2557	.0699	2200.	123088.
				Mean =	121310.
				S.D. =	6664.
302V	3	.2521	.0710	2095.	117045.
303V	3	.2557	.0695	2040.	114793.
304V	3	.2525	.0686	2265.	130762.
305V	3	.2555	.0715	2185.	119606.
306V	3	.2650	.0694	2140.	116361.
307V	3	.2550	.0705	2150.	119594.
				Mean =	119694.
				S.D. =	5739.
296V	5	.2575	.0676	2395.	137588.
297V	5	.2558	.0684	1970.	112593.
298V	5	.2571	.0720	2080.	112364.
299V	5	.2560	.0710	2450.	134793.
300V	5	.2576	.0710	2470.	135049.
301V	5	.2557	.0705	2550.	141456.
				Mean =	128974.
				S.D. =	13000.

Table VII.- Summary of Compression Strength

Material	Location	Baseline		Residual Strength					
				1 year		3 year		5 year	
		Mean*	S.D.**	Mean*	S.D.**	Mean*	S.D.**	Mean*	S.D.**
Kevlar-49/ CE-306		18257.	337.						
	Cameron,LA			17892.	774.	17488.	1239.	----	---
	Gulf of Mexico			17815.	497.	17796.	915.	----	---
	Hampton,VA			19153.	887.	19050.	635.	18001.	679.
	Toronto,Canada			17583.	958.	17003.	905.	17990.	517.
	Ft. Greely,AK			17181.	950.	17533.	592.	17546.	968.
Kevlar-49/ F-185		20176.	489.						
	Cameron,LA			20446.	542.	19333.	560.	----	---
	Gulf of Mexico			19946.	496.	20354.	257.	----	---
	Hampton,VA			19654.	571.	20423.	541.	19691.	407.
	Toronto,Canada			19236.	459.	19308.	417.	19421.	575.
	Ft. Greely,AK			18137.	314.	18899.	438.	18714.	350.
Kevlar-49/ LRF-277		22363.	909.						
	Cameron,LA			21052.	921.	19433.	827.	----	---
	Gulf of Mexico			20810.	635.	19140.	1241.	----	---
	Hampton,VA			19925.	1082.	20051.	1509.	19359.	762.
	Toronto,Canada			19912.	520.	18931.	731.	21134.	481.
	Ft. Greely,AK			18890.	509.	20449.	512.	19677.	1234.
T-300/ E-788		126343.	4025.						
	Cameron,LA			130437.	6510.	115102.	10159.	----	---
	Gulf of Mexico			126787.	9546.	117724.	8282.	----	---
	Hampton,VA			127956.	5870.	126062.	4870.	125195.	8091.
	Toronto,Canada			127306.	3489.	123921.	7234.	127357.	5210.
	Ft. Greely,AK			121310.	6664.	119694.	5739.	128974.	13000.

* Mean of 6 replicates ** S.D.- Standard Deviation

TABLE VIII. - BASELINE SHORT BEAM SHEAR STRENGTH OF COMPOSITE MATERIALS

Material type	Specimen number	Width in.	Thickness in.	Maximum load lbf.	Failure stress psi
K-49/CE-306 Kevlar/epoxy	1F	.2542	.0853	145.	5015.
	2F	.2493	.0946	170.	5406.
	3F	.2505	.0877	157.	5360.
	4F	.2575	.0940	178.	5515.
	5F	.2347	.0848	130.	4899.
	6F	.2461	.0946	170.	5477.
				MEAN =	5279.
				S.D. =	258.
K-49/F-185 Kevlar/epoxy	1	.2625	.0905	190.	5998.
	2	.2628	.0965	202.	5974.
	3	.2613	.0991	205.	5937.
	4	.2612	.0908	195.	6166.
	5	.2630	.0950	210.	6304.
	6	.2650	.0963	195.	5731.
				MEAN =	6018.
				S.D. =	197.
K-49/LRF-277 Kevlar/epoxy	1B	.2425	.0775	95.	3791.
	2B	.2343	.0776	95.	3919.
	3B	.2467	.0774	103.	4046.
	4B	.2634	.0769	105.	3888.
	5B	.2364	.0773	95.	3899.
	6B	.2474	.0779	95.	3697.
				MEAN =	3873.
				S.D. =	119.
T300/E-788 Graphite/ epoxy	1V	.2568	.0720	286.	11601.
	2V	.2562	.0723	266.	10770.
	3V	.2557	.0730	280.	11250.
	4V	.2563	.0734	285.	11362.
	5V	.2564	.0715	270.	11046.
	6V	.2541	.0713	273.	11301.
				MEAN =	11222.
				S.D. =	285.

S.D. = Standard Deviation

TABLE IX. - SHORT BEAM SHEAR STRENGTH OF KEVLAR-49/CE-306
AFTER ENVIRONMENTAL EXPOSURE

(a) exposed at Cameron, LA

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
7F	1	.2577	.0945	176.	5420.
8F	1	.2483	.0880	146.	5011.
9F	1	.2595	.0939	165.	5079.
10F	1	.2457	.0954	165.	5279.
11F	1	.2520	.0946	170.	5348.
12F	1	.2524	.0849	137.	4795.
				Mean =	5156.
				S.D. =	236.
13F	3	.2576	.0943	155.	4786.
14F	3	.2594	.0905	154.	4920.
15F	3	.2594	.0893	144.	4662.
16F	3	.2580	.0927	170.	5331.
17F	3	.2590	.0863	143.	4798.
18F	3	.2426	.0891	144.	4996.
				Mean =	4916.
				S.D. =	234.

(b.) exposed in the Gulf of Mexico

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
37F	1	.2449	.0905	142.	4805.
38F	1	.2578	.0911	158.	5046.
39F	1	.2470	.0881	150.	5170.
40F	1	.2511	.0942	173.	5485.
41F	1	.2443	.0931	156.	5144.
42F	1	.2490	.0905	159.	5292.
				Mean =	5157.
				S.D. =	229.
43F	3	.2469	.0931	179.	5840.
44F	3	.2597	.0902	159.	5091.
45F	3	.2564	.0851	137.	4709.
46F	3	.2611	.0863	148.	4926.
47F	3	.2593	.0943	185.	5674.
48F	3	.2475	.0951	163.	5194.
				Mean =	5239.
				S.D. =	437.

S.D. = Standard deviation

TABLE IX. - CONTINUED

(c) exposed at Hampton, VA

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
67F	1	.2604	.0940	180.	5515.
68F	1	.2442	.0811	129.	4885.
69F	1	.2586	.0961	184.	5553.
70F	1	.2584	.0901	167.	5380.
71F	1	.2542	.0946	180.	5614.
72F	1	.2572	.0904	165.	5322.
				Mean =	5378.
				S.D. =	265.
73F	3	.2473	.0866	148.	5183.
74F	3	.2594	.0847	150.	5103.
75F	3	.2563	.0932	172.	5400.
76F	3	.2457	.0940	175.	5683.
77F	3	.2485	.0938	166.	5341.
78F	3	.2595	.0975	195.	5766.
				Mean =	5413.
				S.D. =	265.
79F	5	.2604	.0928	174.	5400.
80F	5	.2426	.0881	138.	4843.
81F	5	.2549	.0901	168.	5486.
82F	5	.2526	.0967	175.	5373.
83F	5	.2577	.0941	168.	5196.
84F	5	.2564	.0847	142.	4904.
				Mean =	5200.
				S.D. =	271.

TABLE IX. - CONTINUED

(d) exposed at Toronto, Canada

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
97F	1	.2501	.0928	178.	5752.
98F	1	.2597	.0931	190.	5894.
99F	1	.2495	.0881	155.	5289.
100F	1	.2431	.0898	154.	5291.
101F	1	.2488	.0826	140.	5109.
102F	1	.2511	.0946	180.	5683.
				Mean =	5503.
				S.D. =	314.
103F	3	.2576	.0944	190.	5860.
104F	3	.2306	.0868	123.	4609.
105F	3	.2301	.0847	126.	4849.
106F	3	.2577	.0913	175.	5578.
107F	3	.2596	.0884	168.	5491.
108F	3	.2474	.0884	148.	5075.
				Mean =	5244.
				S.D. =	478.
109F	5	.2455	.0945	170.	5496.
110F	5	.2528	.0831	133.	4748.
111F	5	.2442	.0828	132.	4896.
112F	5	.2595	.0857	156.	5261.
113F	5	.2558	.0951	170.	5241.
114F	5	.2544	.0832	130.	4606.
				Mean =	5041.
				S.D. =	344.

TABLE IX. - CONCLUDED

(e) exposed at Ft. Greely,AK

Specimen Number	Exposure Time,yr	Width in.	Thickness in.	Load lbf.	Failure Stress,psi
151F	1	.2562	.0851	129.	4438.
152F	1	.2574	.0926	156.	4909.
153F	1	.2595	.0900	160.	5138.
154F	1	.2572	.0883	153.	5053.
155F	1	.2517	.0882	147.	4966.
156F	1	.2498	.0886	143.	4846.
				Mean =	4892.
				S.D. =	245.
145F	3	.2443	.0915	158.	5284.
146F	3	.2602	.0941	183.	5606.
147F	3	.2586	.0912	175.	5565.
148F	3	.2574	.0935	183.	5703.
149F	3	.2575	.0883	161.	5311.
150F	3	.2592	.0968	184.	5500.
				Mean =	5495.
				S.D. =	167.
139F	5	.2402	.0882	139.	4921.
140F	5	.2544	.0923	164.	5222.
141F	5	.2510	.0833	131.	4699.
142F	5	.2584	.0834	142.	4942.
143F	5	.2568	.0891	155.	5081.
144F	5	.2529	.0940	169.	5316.
				Mean =	5030.
				S.D. =	224.

TABLE X. - SHORT BEAM SHEAR STRENGTH OF KEVLAR-49/F-185 AFTER ENVIRONMENTAL EXPOSURE

(a) exposed at Cameron, LA

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
7	1	.2600	.0942	192.	5879.
8	1	.2618	.0938	193.	5894.
9	1	.2625	.0893	186.	5951.
10	1	.2614	.0946	194.	5884.
11	1	.2622	.0946	194.	5866.
12	1	.2620	.0978	204.	5971.
				Mean =	5908.
				S.D. =	43.
13	3	.2581	.0934	186.	5787.
14	3	.2607	.0968	209.	6211.
15	3	.2598	.0898	177.	5690.
16	3	.2668	.1052	225.	6012.
17	3	.2597	.0965	199.	5955.
18	3	.2592	.0947	206.	6294.
				Mean =	5992.
				S.D. =	234.

(b.) exposed in the Gulf of Mexico

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
37	1	.2627	.0930	190.	5833.
38	1	.2634	.0881	173.	5591.
39	1	.2618	.0901	176.	5596.
40	1	.2720	.0996	205.	5675.
41	1	.2603	.0953	190.	5744.
42	1	.2622	.0927	190.	5863.
				Mean =	5717.
				S.D. =	116.
43	3	.2623	.0977	201.	5883.
44	3	.2624	.0977	220.	6436.
45	3	.2649	.0959	192.	5668.
46	3	.2458	.0893	172.	5877.
47	3	.2518	.0913	190.	6199.
48	3	.2610	.0938	196.	6004.
				Mean =	6011.
				S.D. =	271.

S.D. = Standard deviation

TABLE X. - CONTINUED

(c) exposed at Hampton, VA

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
67	1	.2469	.0894	178.	6048.
68	1	.2600	.0918	190.	5970.
69	1	.2657	.1039	225.	6113.
70	1	.2455	.0923	191.	6322.
71	1	.2743	.1005	230.	6257.
72	1	.2598	.0923	194.	6068.
				Mean =	6130.
				S.D. =	134.
73	3	.2788	.1012	226.	6008.
74	3	.2620	.0940	208.	6334.
75	3	.2606	.0909	194.	6142.
76	3	.2603	.0956	218.	6570.
77	3	.2662	.0960	202.	5928.
78	3	.2581	.0922	195.	6146.
				Mean =	6188.
				S.D. =	233.
79	5	.2534	.1015	209.	6094.
80	5	.2519	.0920	201.	6505.
81	5	.2651	.1050	210.	5658.
82	5	.2636	.1019	196.	5473.
83	5	.2573	.1030	205.	5801.
84	5	.2625	.1032	217.	6008.
				Mean =	5923.
				S.D. =	364.

TABLE X. - CONTINUED

(d) exposed at Toronto, Canada

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
97	1	.2571	.1020	180.	5148.
98	1	.2565	.0877	183.	6101.
99	1	.2503	.1036	195.	5640.
100	1	.2643	.0971	205.	5991.
101	1	.2630	.0961	196.	5816.
102	1	.2644	.1034	220.	6035.
				Mean =	5789.
				S.D. =	356.
103	3	.2622	.0961	201.	5983.
104	3	.2583	.0929	206.	6439.
105	3	.2607	.0828	164.	5698.
106	3	.2533	.1019	209.	6073.
107	3	.2641	.0893	186.	5915.
108	3	.2695	.0812	164.	5621.
				Mean =	5955.
				S.D. =	293.
109	5	.2602	.0900	179.	5733.
110	5	.2602	.0927	194.	6032.
111	5	.2602	.0968	206.	6134.
112	5	.2593	.0971	208.	6196.
113	5	.2612	.0971	209.	6180.
114	5	.2612	.1022	217.	6097.
				Mean =	6062.
				S.D. =	172.

TABLE X. - CONCLUDED

(e) exposed at Ft. Greely,AK

Specimen Number	Exposure Time,yr	Width in.	Thickness in.	Load lbf.	Failure Stress,psi
151	1	.2587	.0907	176.	5626.
152	1	.2674	.0996	207.	5829.
153	1	.2570	.1018	192.	5504.
154	1	.2647	.0931	177.	5387.
155	1	.2612	.0927	188.	5823.
156	1	.2627	.0891	163.	5223.
				Mean =	5565.
				S.D. =	242.
145	3	.2456	.0850	162.	5820.
146	3	.2612	.0922	186.	5793.
147	3	.2450	.0923	191.	6335.
148	3	.2600	.0910	184.	5833.
149	3	.2648	.1050	217.	5853.
150	3	.2635	.0901	184.	5813.
				Mean =	5908.
				S.D. =	210.
139	5	.2633	.0914	180.	5610.
140	5	.2583	.1021	194.	5517.
141	5	.2610	.0970	193.	5718.
142	5	.2623	.0968	178.	5258.
143	5	.2622	.0923	183.	5671.
144	5	.2638	.1040	190.	5194.
				Mean =	5495.
				S.D. =	220.

TABLE XI. - SHORT BEAM SHEAR STRENGTH OF KEVLAR-49/LRF-277
AFTER ENVIRONMENTAL EXPOSURE

(a) exposed at Cameron, IA

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
7B	1	.2419	.0779	95.	3781.
8B	1	.2327	.0776	83.	3447.
9B	1	.2476	.0774	92.	3600.
10B	1	.2309	.0775	85.	3562.
11B	1	.2285	.0784	85.	3559.
12B	1	.2607	.0780	98.	3615.
				Mean =	3594.
				S.D. =	109.
13B	3	.2277	.0780	82.	3463.
14B	3	.2409	.0772	85.	3428.
15B	3	.2352	.0776	79.	3246.
16B	3	.2473	.0764	81.	3215.
17B	3	.2325	.0780	87.	3598.
18B	3	.2367	.0784	83.	3354.
				Mean =	3384.
				S.D. =	143.

(b.) exposed in the Gulf of Mexico

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
37B	1	.2479	.0784	90.	3473.
38B	1	.2559	.0770	95.	3616.
39B	1	.2414	.0810	87.	3337.
40B	1	.2427	.0778	85.	3376.
41B	1	.2470	.0774	90.	3531.
42B	1	.2339	.0768	88.	3674.
				Mean =	3501.
				S.D. =	132.
43B	3	.2247	.0807	80.	3309.
44B	3	.2434	.0773	91.	3627.
45B	3	.2417	.0762	86.	3482.
46B	3	.2445	.0779	89.	3505.
47B	3	.2419	.0784	83.	3282.
48B	3	.2514	.0780	97.	3691.
				Mean =	3483.
				S.D. =	164.

S.D. = Standard deviation

TABLE XI. - CONTINUED

(c) exposed at Hampton, VA

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
67B	1	.2313	.0782	90.	3732.
68B	1	.2429	.0784	96.	3781.
69B	1	.2583	.0778	103.	3844.
70B	1	.2358	.0795	90.	3601.
71B	1	.2468	.0789	97.	3736.
72B	1	.2278	.0780	91.	3841.
				Mean =	3756.
				S.D. =	90.
73B	3	.2402	.0782	86.	3434.
74B	3	.2396	.0800	93.	3639.
75B	3	.2470	.0774	89.	3492.
76B	3	.2352	.0795	86.	3449.
77B	3	.2550	.0780	95.	3582.
78B	3	.2410	.0770	85.	3435.
				Mean =	3505.
				S.D. =	86.
79B	5	.2288	.0796	81.	3336.
80B	5	.2429	.0788	88.	3448.
81B	5	.2528	.0773	94.	3608.
82B	5	.2390	.0785	86.	3438.
83B	5	.2310	.0784	88.	3644.
84B	5	.2398	.0790	88.	3484.
				Mean =	3493.
				S.D. =	115.

TABLE XI. - CONTINUED

(d) exposed at Toronto, Canada

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
97B	1	.2484	.0790	100.	3822.
98B	1	.2398	.0779	90.	3613.
99B	1	.2279	.0780	85.	3586.
100B	1	.2548	.0787	96.	3591.
101B	1	.2242	.0782	85.	3636.
102B	1	.2461	.0769	94.	3725.
				Mean =	3662.
				S.D. =	93.
103B	3	.2508	.0788	89.	3378.
104B	3	.2273	.0804	84.	3447.
105B	3	.2291	.0787	87.	3619.
106B	3	.2456	.0828	95.	3504.
107B	3	.2488	.0776	93.	3613.
108B	3	.2453	.0770	86.	3415.
				Mean =	3496.
				S.D. =	102.
109B	5	.2437	.0793	96.	3726.
110B	5	.2373	.0790	89.	3561.
111B	5	.2393	.0792	97.	3839.
112B	5	.2303	.0802	85.	3452.
113B	5	.2439	.0780	101.	3982.
114B	5	.2300	.0784	93.	3868.
				Mean =	3738.
				S.D. =	200.

TABLE XI. - CONCLUDED

(e) exposed at Ft. Greely,AK

Specimen Number	Exposure Time,yr	Width in.	Thickness in.	Load lbf.	Failure Stress,psi
151B	1	.2411	.0778	84.	3359.
152B	1	.2580	.0780	95.	3541.
153B	1	.2338	.0766	78.	3266.
154B	1	.2452	.0779	88.	3455.
155B	1	.2492	.0798	86.	3243.
156B	1	.2454	.0776	89.	3505.
				Mean =	3395.
				S.D. =	125.
145B	3	.2343	.0777	93.	3811.
146B	3	.2446	.0788	100.	3891.
147B	3	.2473	.0784	86.	3327.
148B	3	.2333	.0786	94.	3824.
149B	3	.2233	.0772	87.	3785.
150B	3	.2373	.0772	89.	3623.
				Mean =	3710.
				S.D. =	208.
139B	5	.2342	.0784	82.	3349.
140B	5	.2372	.0762	78.	3237.
141B	5	.2576	.0773	93.	3484.
142B	5	.2515	.0770	86.	3331.
143B	5	.2322	.0779	83.	3421.
144B	5	.2473	.0761	87.	3467.
				Mean =	3381.
				S.D. =	94.

TABLE XII. - SHORT BEAM SHEAR STRENGTH OF T-300/E-788
AFTER ENVIRONMENTAL EXPOSURE

(a) exposed at Cameron, LA

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
7V	1	.2570	.0708	277.	11418.
8V	1	.2570	.0729	268.	10728.
9V	1	.2579	.0724	303.	12171.
10V	1	.2562	.0733	287.	11462.
11V	1	.2569	.0728	295.	11830.
12V	1	.2570	.0730	258.	10314.
				Mean =	11320.
				S.D. =	689.
13V	3	.2569	.0731	284.	11342.
14V	3	.2565	.0726	284.	11438.
15V	3	.2571	.0714	293.	11971.
16V	3	.2565	.0732	254.	10146.
17V	3	.2573	.0730	303.	12099.
18V	3	.2562	.0721	279.	11328.
				Mean =	11387.
				S.D. =	692.

(b.) exposed in the Gulf of Mexico

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
37V	1	.2563	.0720	270.	10973.
38V	1	.2564	.0724	286.	11555.
39V	1	.2576	.0726	302.	12111.
40V	1	.2579	.0727	298.	11920.
41V	1	.2572	.0701	281.	11689.
42V	1	.2571	.0723	258.	10410.
				Mean =	11443.
				S.D. =	638.
43V	3	.2570	.0715	289.	11796.
44V	3	.2560	.0719	280.	11409.
45V	3	.2569	.0720	289.	11718.
46V	3	.2567	.0710	286.	11769.
47V	3	.2563	.0722	295.	11956.
48V	3	.2554	.0718	274.	11206.
				Mean =	11642.
				S.D. =	279.

S.D. = Standard deviation

TABLE XII. - CONTINUED

(c) exposed at Hampton, VA

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
67V	1	.2555	.0730	281.	11299.
68V	1	.2562	.0713	265.	10880.
69V	1	.2558	.0725	282.	11412.
70V	1	.2576	.0726	280.	11229.
71V	1	.2535	.0726	301.	12266.
72V	1	.2563	.0730	284.	11384.
				Mean =	11412.
				S.D. =	460.
73V	3	.2569	.0728	271.	10868.
74V	3	.2569	.0728	294.	11790.
75V	3	.2570	.0731	295.	11777.
76V	3	.2558	.0735	311.	12406.
77V	3	.2570	.0723	284.	11463.
78V	3	.2562	.0726	293.	11814.
				Mean =	11686.
				S.D. =	505.
79V	5	.2563	.0733	281.	11218.
80V	5	.2564	.0709	299.	12336.
81V	5	.2585	.0729	316.	12577.
82V	5	.2576	.0710	284.	11646.
83V	5	.2564	.0731	282.	11284.
84V	5	.2568	.0725	256.	10313.
				Mean =	11562.
				S.D. =	824.

TABLE XII. - CONTINUED

(d) exposed at Toronto, Canada

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
97V	1	.2563	.0725	260.	10494.
98V	1	.2571	.0714	292.	11930.
99V	1	.2566	.0728	275.	11041.
100V	1	.2579	.0727	285.	11400.
101V	1	.2562	.0734	305.	12164.
102V	1	.2570	.0723	260.	10495.
				Mean =	11254.
				S.D. =	708.
103V	3	.2575	.0725	300.	12052.
104V	3	.2562	.0728	263.	10576.
105V	3	.2580	.0723	308.	12384.
106V	3	.2562	.0705	291.	12083.
107V	3	.2567	.0725	302.	12170.
108V	3	.2535	.0729	309.	12540.
				Mean =	11968.
				S.D. =	707.
109V	5	.2563	.0732	309.	12353.
110V	5	.2580	.0733	296.	11739.
111V	5	.2572	.0765	258.	9834.
112V	5	.2564	.0725	290.	11700.
113V	5	.2563	.0724	306.	12368.
114V	5	.2573	.0740	302.	11896.
				Mean =	11648.
				S.D. =	936.

TABLE XII. - CONCLUDED

(e) exposed at Ft. Greely, AK

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
151V	1	.2564	.0731	265.	10604.
152V	1	.2570	.0712	272.	11149.
153V	1	.2564	.0712	268.	11010.
154V	1	.2570	.0726	271.	10893.
155V	1	.2569	.0722	255.	10311.
156V	1	.2563	.0727	275.	11069.
				Mean =	10839.
				S.D. =	321.
145V	3	.2557	.0718	251.	10254.
146V	3	.2569	.0727	264.	10601.
147V	3	.2563	.0722	304.	12321.
148V	3	.2569	.0727	273.	10963.
149V	3	.2570	.0723	275.	11100.
150V	3	.2560	.0724	271.	10966.
				Mean =	11034.
				S.D. =	702.
139V	5	.2563	.0736	265.	10536.
140V	5	.2569	.0718	265.	10775.
141V	5	.2559	.0712	251.	10332.
142V	5	.2570	.0722	258.	10428.
143V	5	.2583	.0730	269.	10700.
144V	5	.2566	.0722	293.	11861.
				Mean =	10772.
				S.D. =	558.

Table XIII.- Summary of Short Beam Shear Strength

Material	Location	Baseline		Residual Strength 1 year		Residual Strength 3 year		Residual Strength 5 year	
		Mean*	S.D.**	Mean*	S.D.**	Mean*	S.D.**	Mean*	S.D.**
Kevlar-49/ CE-306		5279.	258.						
	Cameron, LA			5156.	236.	4916.	234.	----	---
	Gulf of Mexico			5157.	229.	5239.	437.	----	---
	Hampton, VA			5378.	265.	5413.	265.	5200.	271.
	Toronto, Canada			5503.	314.	5244.	478.	5041.	344.
	Ft. Greely, AK			4892.	245.	5495.	167.	5030.	224.
Kevlar-49/ F-185		6018.	197.						
	Cameron, LA			5908.	43.	5992.	234.	----	---
	Gulf of Mexico			5717.	116.	6011.	271.	----	---
	Hampton, VA			6130.	134.	6188.	233.	5923.	364.
	Toronto, Canada			5789.	356.	5955.	293.	6062.	172.
	Ft. Greely, AK			5565.	242.	5908.	210.	5495.	220.
Kevlar-49/ LRF-277		3783.	119.						
	Cameron, LA			3594.	109.	3384.	143.	----	---
	Gulf of Mexico			3501.	132.	3483.	164.	----	---
	Hampton, VA			3756.	90.	3505.	86.	3493.	115.
	Toronto, Canada			3662.	93.	3496.	102.	3738.	200.
	Ft. Greely, AK			3395.	125.	3710.	208.	3381.	94.
T-300/ E-788		11222.	285.						
	Cameron, LA			11320.	689.	11387.	692.	----	---
	Gulf of Mexico			11443.	638.	11642.	279.	----	---
	Hampton, VA			11412.	460.	11686.	505.	11562.	824.
	Toronto, Canada			11254.	708.	11968.	707.	11648.	936.
	Ft. Greely, AK			10389.	321.	11034.	702.	10772.	558.

* Mean of 6 replicates ** S.D.- Standard Deviation

TABLE XIV. - BASELINE TENSION STRENGTH OF COMPOSITE MATERIALS

Material type	Specimen number	Width in.	Thickness in.	Maximum load lbf.	Failure stress psi
K-49/CE-306 Kevlar/epoxy	157F	.9868	.0969	5520.	57728.
	158F	.9752	.0897	5460.	62418.
	159F	.9827	.0967	6120.	64403.
	160F	.9952	.0979	5790.	59427.
	161F	.9960	.0994	5790.	58483.
	162F	.9895	.0966	6125.	64079.
				Mean =	61090.
				S.D. =	2917.
K-49/F-185 Kevlar/epoxy	160	1.0075	.1063	6020.	56211.
	161	1.0070	.1042	5890.	56133.
	162	1.0046	.1042	5870.	56076.
	163	1.0058	.1045	6080.	57846.
	164	.9966	.0969	6000.	62131.
	165	1.0053	.1004	5630.	55780.
				Mean =	57363.
				S.D. =	2448.
K-49/LRF-277 Kevlar/epoxy	157B	.9857	.0865	7100.	83272.
	158B	.9842	.0884	7150.	82181.
	159B	.9710	.0868	7140.	84715.
	160B	1.0002	.0868	6970.	80283.
	161B	.9955	.0863	7320.	85204.
	162B	.9728	.0872	7320.	86292.
				Mean =	83658.
				S.D. =	2198.
T300/E-788 Graphite/ epoxy	325V	1.0032	.0700	9210.	131152.
	326V	1.0030	.0696	8710.	124769.
	327V	1.0047	.0702	8580.	121650.
	328V	1.0090	.0705	9180.	129051.
	329V	1.0048	.0684	8950.	130223.
	330V	1.0057	.0722	8860.	122019.
				Mean =	126477.
				S.D. =	4209.

S.D. = Standard Deviation

TABLE XV. - TENSION STRENGTH OF KEVLAR-49/CE-306
AFTER ENVIRONMENTAL EXPOSURE

(a) exposed at Cameron, LA

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
163F	1	.9756	.0894	5080.	58244.
164F	1	.9915	.0982	5900.	60597.
165F	1	.9949	.0972	6030.	62355.
166F	1	.9896	.0958	5780.	60968.
167F	1	.9937	.0980	6030.	61921.
168F	1	.9901	.1001	6260.	63163.
				Mean =	61208.
				S.D. =	1724.
169F	3	.9932	.0969	5955.	61876.
170F	3	.9807	.0922	5425.	59997.
171F	3	.9943	.0980	5820.	59728.
172F	3	1.0020	.0930	5780.	62026.
173F	3	.9968	.0973	5800.	59801.
174F	3	.9864	.0973	5690.	59285.
				Mean =	60452.
				S.D. =	1185.

(b.) exposed in the Gulf of Mexico

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
193F	1	.9971	.0975	5890.	60586.
194F	1	.9978	.0995	6160.	62046.
195F	1	.9812	.0988	6090.	62821.
196F	1	.9800	.0974	5800.	60764.
197F	1	1.0027	.0966	5760.	59467.
198F	1	.9970	.0974	6080.	62611.
				Mean =	61382.
				S.D. =	1319.
199F	3	.9952	.0966	5950.	61891.
200F	3	.9994	.0976	5650.	57924.
201F	3	.9963	.0909	5700.	62939.
202F	3	.9944	.0998	6000.	60459.
203F	3	.9963	.0985	6000.	61140.
204F	3	.9948	.0962	6150.	64263.
				Mean =	61436.
				S.D. =	2183.

S.D. = Standard deviation

TABLE XV. - CONTINUED

(c) exposed at Hampton, VA

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
223F	1	.9934	.0987	6350.	64764.
224F	1	.9461	.0979	5760.	62187.
225F	1	.9750	.0988	6080.	63116.
226F	1	.9848	.0962	6150.	64916.
227F	1	.9848	.0973	6240.	65121.
228F	1	.9828	.0978	6060.	63048.
				Mean =	63859.
				S.D. =	1227.
229F	3	.9904	.0982	6170.	63440.
230F	3	.9833	.0969	6080.	63811.
231F	3	.9771	.0964	6010.	63806.
232F	3	.9850	.0970	6150.	64368.
233F	3	.9798	.0961	5960.	63297.
234F	3	.9863	.0994	6150.	62731.
				Mean =	63575.
				S.D. =	556.
235F	5	.9973	.0977	6055.	62143.
236F	5	1.0102	.0971	6200.	63207.
237F	5	.9854	.0974	5700.	59389.
238F	5	.9980	.0923	5830.	63290.
239F	5	.9958	.0915	5525.	60637.
240F	5	.9801	.0982	5900.	61301.
				Mean =	61661.
				S.D. =	1524.

TABLE XV. - CONTINUED

(d) exposed at Toronto, Canada

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
253F	1	.9857	.0975	6000.	62431.
254F	1	.9960	.0965	6300.	65547.
255F	1	.9865	.0978	6000.	62189.
256F	1	.9870	.0989	6100.	62491.
257F	1	.9844	.0970	6250.	65454.
258F	1	.9892	.0967	6000.	62725.
				Mean =	63473.
				S.D. =	1580.
259F	3	.9964	.0963	6290.	65553.
260F	3	.9970	.0950	6050.	63876.
261F	3	.9929	.0982	6100.	62562.
262F	3	.9877	.0973	6200.	64514.
263F	3	.9903	.1000	6150.	62102.
264F	3	.9852	.0991	6250.	64015.
				Mean =	63770.
				S.D. =	1268.
265F	5	.9828	.0944	5600.	60360.
266F	5	.9941	.0967	6150.	63976.
267F	5	.9945	.0981	5925.	60732.
268F	5	.9833	.0974	6080.	63483.
269F	5	.9931	.0995	5990.	60619.
270F	5	.9919	.0982	6200.	63652.
				Mean =	62137.
				S.D. =	1728.

TABLE XV. - CONCLUDED

(e) exposed at Ft. Greely, AK

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
307F	1	.9941	.0895	5580.	62716.
308F	1	.9905	.0961	5870.	61668.
309F	1	.9926	.0978	6090.	62734.
310F	1	.9795	.0901	5720.	64814.
311F	1	1.0008	.0989	6280.	63448.
312F	1	.9931	.0978	5900.	60746.
				Mean =	62688.
				S.D. =	1408.
301F	3	.9890	.0903	5750.	64385.
302F	3	.9932	.0983	6300.	64528.
303F	3	.9928	.0962	6110.	63974.
304F	3	.9933	.0992	6060.	61501.
305F	3	.9947	.0992	6010.	60907.
306F	3	.9966	.0972	6050.	62455.
				Mean =	62958.
				S.D. =	1557.
295F	5	.9961	.0997	5920.	59611.
296F	5	1.0015	.0982	6050.	61517.
297F	5	.9882	.0937	5300.	57239.
298F	5	.9837	.0942	5500.	59354.
299F	5	.9995	.0984	6080.	61820.
300F	5	.9880	.0974	6300.	65467.
				Mean =	60834.
				S.D. =	2811.

TABLE XVI. - TENSION STRENGTH OF KEVLAR-49/F-185
AFTER ENVIRONMENTAL EXPOSURE

(a) exposed at Cameron, IA

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
166	1	1.0023	.1073	6080.	56534.
167	1	.9928	.1020	6000.	59250.
168	1	1.0066	.1014	5940.	58196.
169	1	1.0048	.1051	6010.	56910.
170	1	1.0034	.0960	5850.	60731.
171	1	1.0095	.0967	5825.	59671.
				Mean =	58549.
				S.D. =	1636.
172	3	1.0041	.1040	5860.	56116.
173	3	1.0047	.0967	5900.	60728.
174	3	1.0040	.1032	5830.	56267.
175	3	1.0043	.1000	6030.	60042.
176	3	.9971	.0947	5750.	60895.
177	3	.9924	.0993	6025.	61139.
				Mean =	59198.
				S.D. =	2357.

(b.) exposed in the Gulf of Mexico

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
196	1	1.0013	.1058	6240.	58903.
197	1	1.0063	.1029	6030.	58234.
198	1	.9859	.0978	5840.	60568.
199	1	1.0040	.1042	5950.	56874.
200	1	.9983	.1085	5880.	54286.
201	1	1.0034	.1029	6000.	58111.
				Mean =	57829.
				S.D. =	2115.
202	3	.9942	.0932	5630.	60760.
203	3	1.0079	.0964	5950.	61238.
204	3	1.0049	.1021	6010.	58577.
205	3	1.0027	.1024	5810.	56586.
206	3	1.0011	.1000	5960.	59535.
207	3	.9942	.0991	5780.	58665.
				Mean =	59227.
				S.D. =	1686.

TABLE XVI. - CONTINUED

(c) exposed at Hampton, VA

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
226	1	1.0040	.0946	6190.	65173.
227	1	.9999	.1003	6060.	60425.
228	1	1.0041	.1000	6020.	59954.
229	1	1.0000	.1004	5810.	57869.
230	1	.9998	.1001	5730.	57254.
231	1	1.0003	.1006	6000.	59624.
				Mean =	60050.
				S.D. =	2798.
232	3	1.0006	.1008	6250.	61967.
233	3	.9998	.1022	6180.	60482.
234	3	1.0000	.0999	6100.	61061.
235	3	1.0007	.1003	5990.	59679.
236	3	1.0050	.1001	5990.	59542.
237	3	1.0020	.1006	6240.	61904.
				Mean =	60773.
				S.D. =	1057.
238	5	1.0030	.0992	6100.	61308.
239	5	1.0050	.1008	6025.	59474.
240	5	1.0055	.1000	5930.	58976.
241	5	1.0020	.0997	6000.	60060.
242	5	1.0070	.0899	5500.	60754.
243	5	1.0025	.0992	5880.	59126.
				Mean =	59950.
				S.D. =	933.

TABLE XVI. - CONTINUED

(d) exposed at Toronto, Canada

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
256	1	1.0000	.1005	6100.	60697.
257	1	1.0000	.1004	6150.	61255.
258	1	1.0040	.1005	6250.	61941.
259	1	1.0040	.0999	5950.	59322.
260	1	1.0035	.0999	5950.	59352.
261	1	1.0000	.1003	5500.	54835.
				Mean =	59567.
				S.D. =	2540.
262	3	1.0035	.0998	6250.	62407.
263	3	1.0000	.1005	6020.	59900.
264	3	1.0010	.1004	6090.	60597.
265	3	1.0040	.1000	5850.	58267.
266	3	1.0055	.1005	6050.	59870.
267	3	1.0080	.0998	6080.	60438.
				Mean =	60247.
				S.D. =	1342.
268	5	1.0015	.1000	6075.	60659.
269	5	.9998	.0991	5900.	59548.
270	5	1.0011	.1003	5800.	57763.
271	5	1.0035	.1004	6125.	60793.
272	5	1.0055	.1004	5890.	58344.
273	5	1.0040	.0989	5975.	60174.
				Mean =	59547.
				S.D. =	1250.

TABLE XVI. - CONCLUDED

(e) exposed at Ft. Greely, AK

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
310	1	1.0002	.1004	6050.	60247.
311	1	1.0004	.1003	4880.	48635.
312	1	1.0005	.1003	6120.	60986.
313	1	1.0005	.1003	6220.	61983.
314	1	1.0004	.1001	6150.	61414.
315	1	1.0001	.1006	6075.	60382.
				Mean =	58941.
				S.D. =	5090.
304	3	1.0003	.1008	6080.	60299.
305	3	1.0002	.0997	5790.	58063.
306	3	1.0000	.0994	5850.	58853.
307	3	1.0007	.1004	6150.	61212.
308	3	1.0000	.1004	6140.	61155.
309	3	1.0001	.1005	6110.	60790.
				Mean =	60062.
				S.D. =	1309.
298	5	1.0002	.1007	6190.	61457.
299	5	1.0000	.1001	6060.	60539.
300	5	1.0007	.1008	6055.	60027.
301	5	1.0002	.0998	6120.	61310.
302	5	1.0003	.1005	6155.	61225.
303	5	1.0001	.1001	5990.	59834.
				Mean =	60732.
				S.D. =	699.

TABLE XVII. - TENSION STRENGTH OF KEVLAR-49/LRF-277
AFTER ENVIRONMENTAL EXPOSURE

(a) exposed at Cameron, LA

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
163B	1	.9813	.0887	7780.	89383.
164B	1	1.0060	.0873	7210.	82096.
165B	1	.9813	.0874	7650.	89197.
166B	1	.9925	.0870	6910.	80025.
167B	1	.9905	.0855	7480.	88324.
168B	1	.9829	.0859	7600.	90014.
				Mean =	86507.
				S.D. =	4303.
169B	3	.9792	.0870	7320.	85925.
170B	3	.9902	.0886	7450.	84918.
171B	3	.9965	.0857	7740.	90632.
172B	3	1.0052	.0874	7760.	88328.
173B	3	.9820	.0883	7590.	87533.
174B	3	.9678	.0864	7090.	84790.
				Mean =	87021.
				S.D. =	2263.

(b.) exposed in the Gulf of Mexico

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
193B	1	.9948	.0880	7360.	84074.
194B	1	1.0094	.0882	6290.	70651.
195B	1	.9980	.0881	8025.	91272.
196B	1	.9808	.0894	7580.	86447.
197B	1	.9791	.0869	7410.	87091.
198B	1	1.0024	.0885	6990.	78794.
				Mean =	83055.
				S.D. =	7326.
199B	3	.9813	.0853	7020.	83866.
200B	3	.9926	.0879	7600.	87106.
201B	3	.9967	.0882	7790.	88614.
202B	3	1.0046	.0856	7000.	81401.
203B	3	.9838	.0875	7790.	90495.
204B	3	1.0119	.0865	7250.	82829.
				Mean =	85719.
				S.D. =	3565.

TABLE XVII. - CONTINUED

(c) exposed at Hampton, VA

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
223B	1	.9892	.0891	7810.	88611.
224B	1	.9841	.0922	7850.	86517.
225B	1	.9875	.0874	6950.	80526.
226B	1	1.0054	.0847	7260.	85254.
227B	1	1.0011	.0864	7300.	84398.
228B	1	.9935	.0880	6870.	78579.
				Mean =	83981.
				S.D. =	3763.
229B	3	.9810	.0883	7820.	90277.
230B	3	.9776	.0892	6630.	76030.
231B	3	.9803	.0872	7700.	90077.
232B	3	.9834	.0895	7390.	83964.
233B	3	.9907	.0867	7980.	92906.
234B	3	.9938	.0866	7150.	83079.
				Mean =	86055.
				S.D. =	6240.
235B	5	.9740	.0868	7520.	88949.
236B	5	.9898	.0868	7700.	89624.
237B	5	.9798	.0871	7260.	85071.
238B	5	.9866	.0871	7600.	88441.
239B	5	.9992	.0875	7975.	91216.
240B	5	.9942	.0861	7490.	87499.
				Mean =	88467.
				S.D. =	2078.

TABLE XVII. - CONTINUED

(d) exposed at Toronto, Canada

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
253B	1	.9871	.0882	7500.	86145.
254B	1	.9972	.0880	7650.	87176.
255B	1	.9952	.0871	7700.	88831.
256B	1	.9812	.0893	7600.	86737.
257B	1	.9916	.0861	7100.	83161.
258B	1	.9682	.0875	7500.	88530.
				Mean =	86763.
				S.D. =	2046.
259B	3	.9823	.0894	7800.	88820.
260B	3	.9833	.0866	7300.	85727.
261B	3	.9835	.0893	7675.	87388.
262B	3	.9900	.0872	7730.	89542.
263B	3	.9853	.0880	7190.	82924.
264B	3	.9949	.0894	8080.	90844.
				Mean =	87541.
				S.D. =	2870.
265B	5	.9866	.0857	6930.	81962.
266B	5	1.0022	.0862	7110.	82302.
267B	5	.9843	.0885	7575.	86958.
268B	5	.9730	.0853	7110.	85666.
269B	5	.9785	.0873	7490.	87681.
270B	5	.9793	.0879	7395.	85908.
				Mean =	85079.
				S.D. =	2399.

TABLE XVII. - CONCLUDED

(e) exposed at Ft. Greely,AK

Specimen Number	Exposure Time,yr	Width in.	Thickness in.	Load lbf.	Failure Stress,psi
307B	1	.9862	.0867	6450.	75435.
308B	1	1.0124	.0851	7570.	87865.
309B	1	.9880	.0901	8020.	90093.
310B	1	.9922	.0887	7830.	88969.
311B	1	.9968	.0873	7750.	89059.
312B	1	.9762	.0887	7070.	81650.
				Mean =	85512.
				S.D. =	5788.
301B	3	.9910	.0877	7650.	88021.
302B	3	.9960	.0875	7340.	84223.
303B	3	.9940	.0866	7610.	88406.
304B	3	.9986	.0895	7060.	78993.
305B	3	.9916	.0889	7560.	85760.
306B	3	.9700	.0851	6290.	76199.
				Mean =	83600.
				S.D. =	4974.
295B	5	.9665	.0885	7830.	91541.
296B	5	1.0005	.0882	8015.	90828.
297B	5	.9842	.0885	7480.	85877.
298B	5	.9902	.0870	7850.	91123.
299B	5	.9842	.0867	7450.	87308.
300B	5	.9895	.0893	7660.	86689.
				Mean =	88894.
				S.D. =	2538.

TABLE XVIII. - TENSION STRENGTH OF T-300/E-788 AFTER ENVIRONMENTAL EXPOSURE

(a) exposed at Cameron, LA

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
331V	1	1.0030	.0710	8530.	119782.
332V	1	.9999	.0703	8900.	126613.
333V	1	.9998	.0726	8990.	123854.
334V	1	1.0079	.0742	9420.	125959.
335V	1	1.0021	.0708	8460.	119241.
336V	1	.9999	.0718	8700.	121182.
				Mean =	122772.
				S.D. =	3163.
337V	3	.9998	.0716	9380.	131032.
338V	3	1.0048	.0712	8230.	115038.
339V	3	1.0095	.0702	9770.	137864.
340V	3	1.0058	.0707	9610.	135143.
341V	3	1.0039	.0705	8440.	119251.
342V	3	.9997	.0680	8660.	127391.
				Mean =	127620.
				S.D. =	8962.

(b.) exposed in the Gulf of Mexico

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
361V	1	1.0023	.0701	9080.	129232.
362V	1	1.0010	.0713	8130.	113911.
363V	1	.9998	.0690	9300.	134810.
364V	1	.9997	.0722	8540.	118318.
365V	1	1.0000	.0718	8980.	125070.
366V	1	1.0010	.0717	8410.	117177.
				Mean =	123086.
				S.D. =	8012.
367V	3	1.0053	.0728	9660.	131993.
368V	3	1.0030	.0716	8420.	117246.
369V	3	1.0030	.0713	9250.	129345.
370V	3	1.0015	.0691	9390.	135686.
371V	3	1.0058	.0706	9400.	132377.
372V	3	1.0068	.0723	8650.	118832.
				Mean =	127580.
				S.D. =	7676.

TABLE XVIII. - CONTINUED

(c) exposed at Hampton, VA

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
391V	1	1.0010	.0691	9090.	131417.
392V	1	1.0037	.0699	8840.	126000.
393V	1	1.0018	.0723	8840.	122049.
394V	1	1.0080	.0697	9150.	130235.
395V	1	1.0016	.0709	9060.	127581.
396V	1	1.0010	.0707	9220.	130280.
				Mean =	127927.
				S.D. =	3505.
397V	3	.9994	.0726	8650.	119218.
398V	3	.9999	.0703	9270.	131877.
399V	3	1.0043	.0714	8660.	120769.
400V	3	1.0020	.0692	9600.	138451.
401V	3	1.0060	.0705	8810.	124219.
402V	3	.9992	.0703	9490.	135101.
				Mean =	128272.
				S.D. =	7974.
403V	5	1.0025	.0714	9550.	133420.
404V	5	1.0053	.0724	9230.	126814.
405V	5	.9987	.0713	9650.	135520.
406V	5	1.0033	.0694	9210.	132272.
407V	5	1.0042	.0711	9270.	129834.
408V	5	1.0042	.0722	9210.	127029.
				Mean =	130815.
				S.D. =	3531.

TABLE XVIII. - CONTINUED

(d) exposed at Toronto, Canada

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
421V	1	.9995	.0689	9550.	138676.
422V	1	1.0062	.0695	9450.	135133.
423V	1	1.0000	.0707	9775.	138260.
424V	1	.9999	.0692	9725.	140549.
425V	1	1.0045	.0697	9570.	136688.
426V	1	.9992	.0692	8850.	127993.
				Mean =	136216.
				S.D. =	4428.
427V	3	.9990	.0687	9420.	137255.
428V	3	1.0065	.0727	9490.	129693.
429V	3	1.0000	.0719	9560.	132962.
430V	3	1.0060	.0716	9140.	126892.
431V	3	1.0070	.0693	8640.	123809.
432V	3	1.0018	.0722	8730.	120697.
				Mean =	128551.
				S.D. =	6057.
433V	5	1.0072	.0719	8525.	117720.
434V	5	1.0070	.0690	8840.	127225.
435V	5	1.0040	.0706	8525.	120270.
436V	5	1.0061	.0703	8980.	126964.
437V	5	1.0043	.0702	8710.	123543.
438V	5	1.0080	.0722	9100.	125038.
				Mean =	123460.
				S.D. =	3797.

TABLE XVIII. - CONCLUDED

(e) exposed at Ft. Greely, AK

Specimen Number	Exposure Time, yr	Width in.	Thickness in.	Load lbf.	Failure Stress, psi
475V	1	1.0035	.0725	8160.	112159.
476V	1	1.0040	.0713	9000.	125724.
477V	1	1.0065	.0721	10625.	146413.
478V	1	.9992	.0698	7990.	114562.
479V	1	1.0003	.0698	9080.	130047.
480V	1	1.0030	.0704	9350.	132415.
				Mean =	126887.
				S.D. =	12586.
469V	3	.9997	.0697	9450.	135622.
470V	3	1.0031	.0686	9060.	131662.
471V	3	1.0010	.0694	9390.	135167.
472V	3	.9997	.0685	9420.	137560.
473V	3	1.0062	.0705	9060.	127719.
474V	3	.9995	.0683	9560.	140041.
				Mean =	134628.
				S.D. =	4375.
463V	5	1.0050	.0690	9360.	134977.
464V	5	1.0030	.0715	9625.	134213.
465V	5	1.0060	.0714	9790.	136297.
466V	5	1.0027	.0706	9100.	128548.
467V	5	1.0000	.0712	9780.	137360.
468V	5	1.0053	.0722	10580.	145765.
				Mean =	136193.
				S.D. =	5601.

Table XIX.- Summary of Tension Strength

Material	Location	Baseline		Residual Strength					
				1 year		3 year		5 year	
		Mean*	S.D.**	Mean*	S.D.**	Mean*	S.D.**	Mean*	S.D.**
Kevlar-49/ CE-306		61090.	2917.						
	Cameron,LA			61208.	1724.	60452.	1185.	----	----
	Gulf of Mexico			61382.	1319.	61436.	2183.	----	----
	Hampton,VA			63859.	1227.	63575.	556.	61661.	1524.
	Toronto,Canada			63473.	1580.	63770.	1268.	62137.	1728.
	Ft. Greely,AK			62688.	1408.	62958.	1557.	60384.	2811.
Kevlar-49/ F-185		57363.	2448.						
	Cameron,LA			58549.	1636.	59198.	2357.	----	----
	Gulf of Mexico			57829.	2115.	59227.	1686.	----	----
	Hampton,VA			60050.	2798.	60773.	1057.	59950.	933.
	Toronto,Canada			59567.	2540.	60247.	1342.	59547.	1250.
	Ft. Greely,AK			58941.	5090.	60062.	1309.	60732.	699.
Kevlar-49/ LRF-277		83658.	2198.						
	Cameron,LA			86507.	4303.	87021.	2263.	----	----
	Gulf of Mexico			83055.	7326.	85719.	3565.	----	----
	Hampton,VA			83981.	3763.	86055.	6240.	88467.	2078.
	Toronto,Canada			86763.	2046.	87541.	2870.	80579.	2399.
	Ft. Greely,AK			85512.	5788.	83600.	4974.	88894.	2538.
T-300/ E-788		126477.	4209.						
	Cameron,LA			122772.	3163.	127620.	8962.	-----	----
	Gulf of Mexico			123086.	8012.	127580.	7676.	-----	----
	Hampton,VA			127927.	3505.	128272.	7974.	130815.	3531.
	Toronto,Canada			136216.	4428.	128551.	6057.	123460.	3797.
	Ft. Greely,AK			126887.	12586.	134628.	4375.	136193.	5601.

* Mean of 6 replicates   ** S.D.- Standard Deviation

TABLE XX. - WEIGHT LOSS OF PAINTED SPECIMENS AFTER
3 AND 5 YEARS OF EXPOSURE

	Kevlar-49/ F-185		Kevlar-49/ LRF-277		Kevlar-49/ CE-306		T-300/ E-788	
	3 yr	5 yr	3 yr	5 yr	3 yr	5 yr	3 yr	5 yr
Ontario, Canada	2.23	2.60	2.03	2.20	2.07	2.20	0.54	0.71
Hampton, VA	2.42	2.76	1.81	2.24	1.74	2.29	0.51	0.76
Gulf of Mexico	2.61	-	1.92	-	1.81	-	0.49	-
Cameron, LA	2.57	-	1.96	-	1.95	-	0.51	-
Ft. Greely, AK	2.18	2.30	1.94	2.10	2.20	2.20	0.67	0.75
Average	2.40	2.55	1.93	2.18	1.95	2.23	0.56	0.74

All values are average of 6 replicates

TABLE XXI. - WEIGHT LOSS OF UNPAINTED SPECIMENS AFTER
3 AND 5 YEARS OF EXPOSURE TIME

	Kevlar-49/ F-185		Kevlar-49/ LRF-277		Kevlar-49/ CE-306		T-300/ E-788	
	3 yr	5 yr	3 yr	5 yr	3 yr	5 yr	3 yr	5 yr
Ontario, Canada	1.60	1.90	2.01	2.40	1.85	1.90	0.51	0.62
Hampton, VA	1.69	2.05	2.71	2.11	1.62	1.96	0.47	0.60
Gulf of Mexico	2.03	-	2.36	-	2.03	-	0.74	-
Cameron, LA	1.87	-	2.11	-	1.97	-	0.50	-
Ft. Greely, AK	1.79	1.80	2.09	2.30	1.59	1.70	0.54	0.61
Average	1.80	1.92	2.23	2.27	1.81	1.85	0.55	0.61

All values are from a single data point

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BLACK AND WHITE PHOTOGRAPH

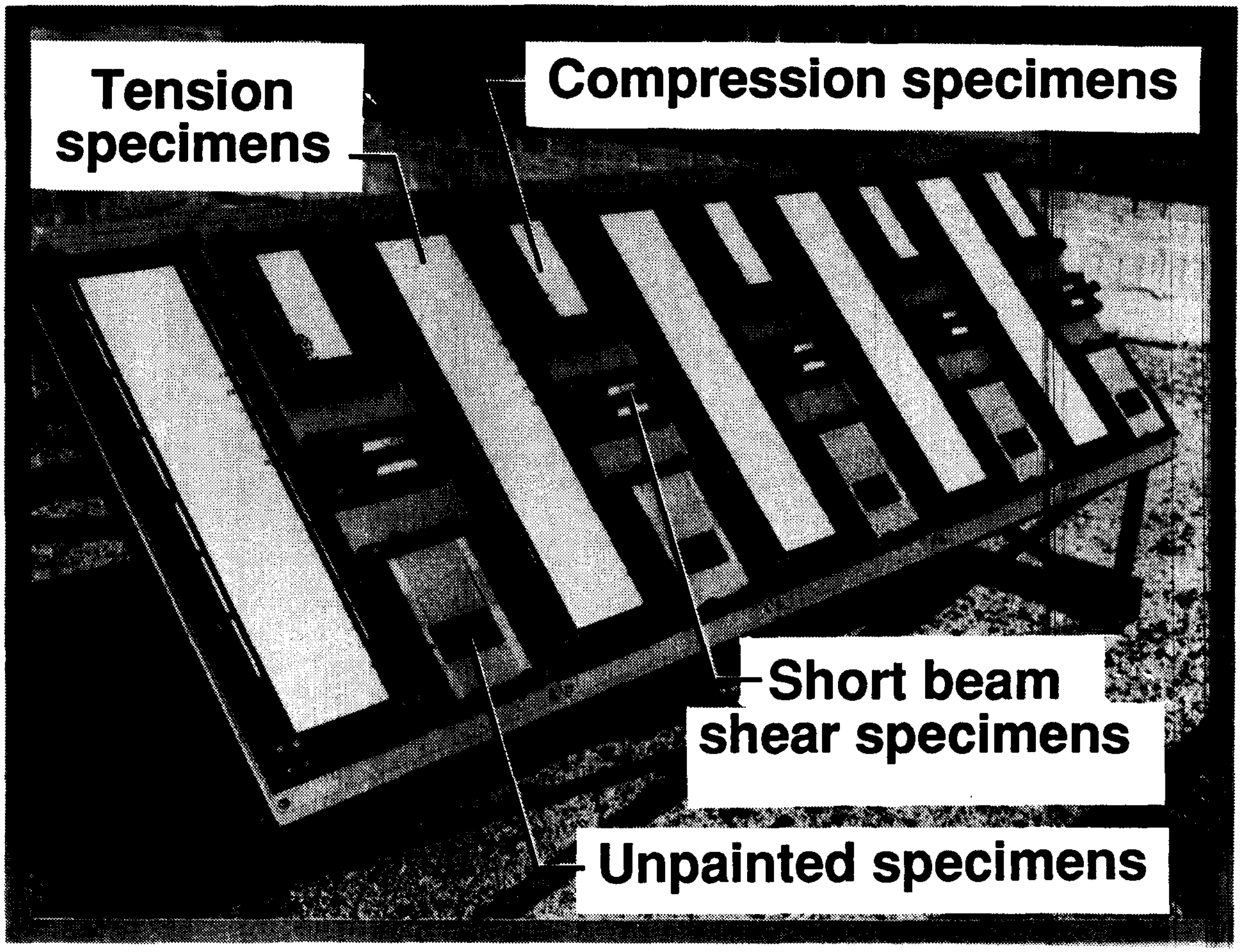


Figure 1. - Environmental Exposure Rack with Specimens installed

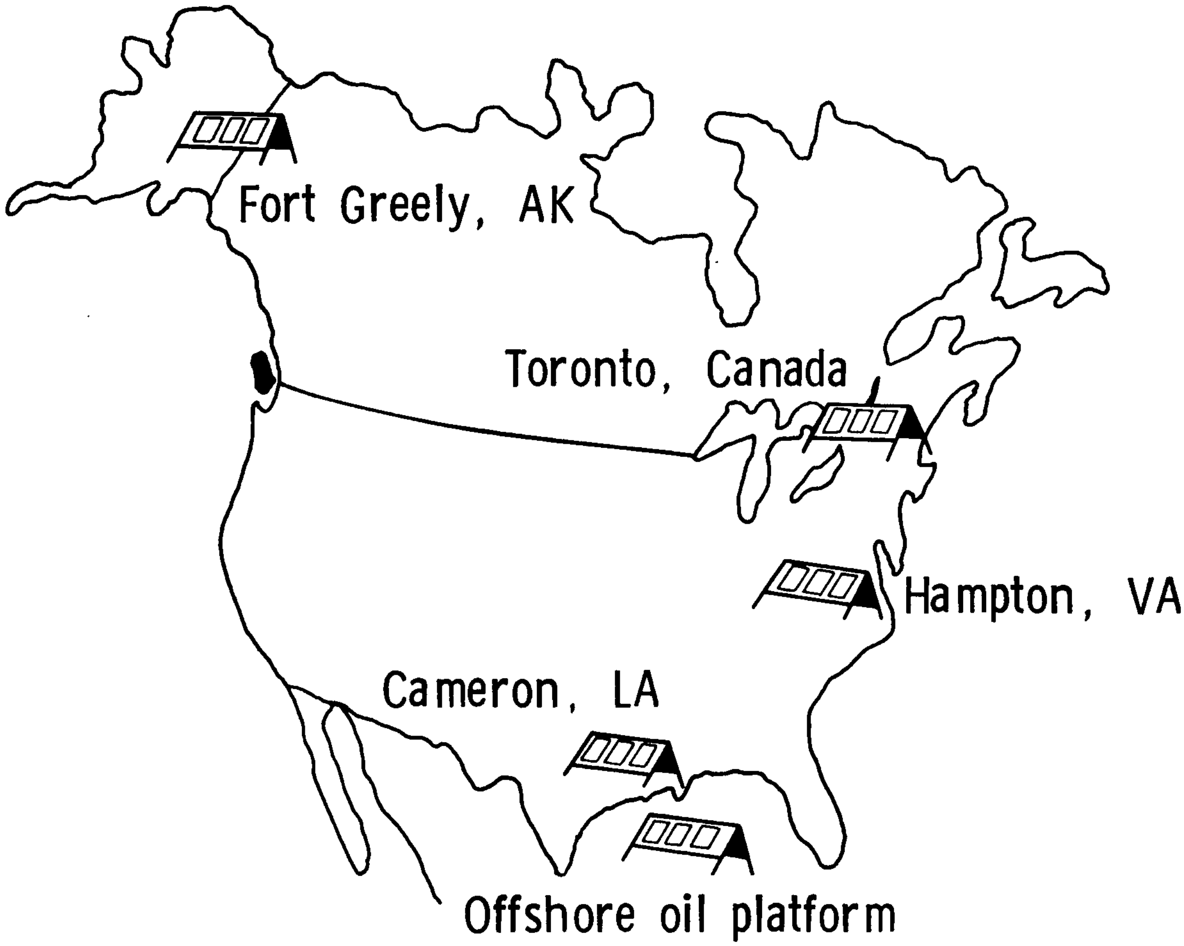


Figure 2. - Location of Environmental Exposure Racks

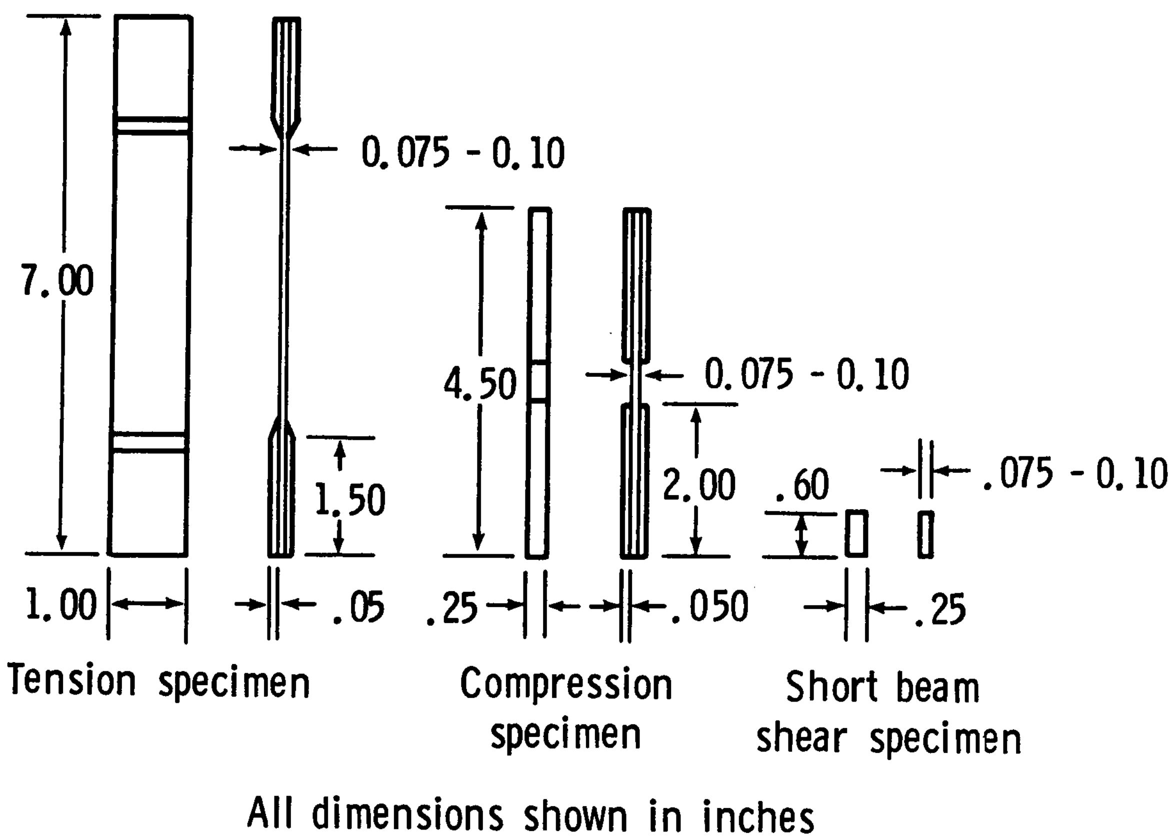


Figure 3. - Specimen Geometry

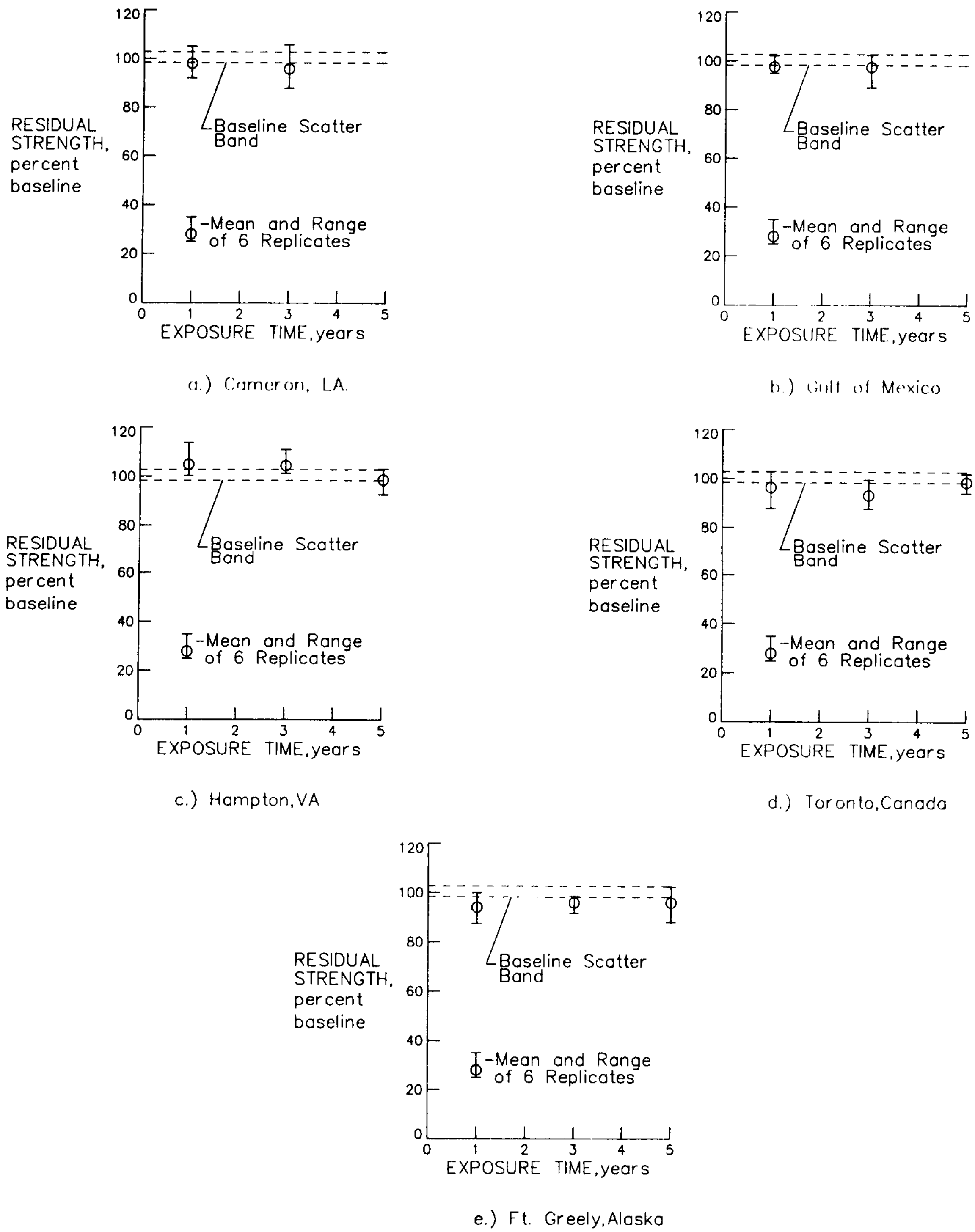


Figure 4.–Residual Compressive Strength of Kevlar-49/CE-306 Epoxy Specimens Exposed at Locations Shown

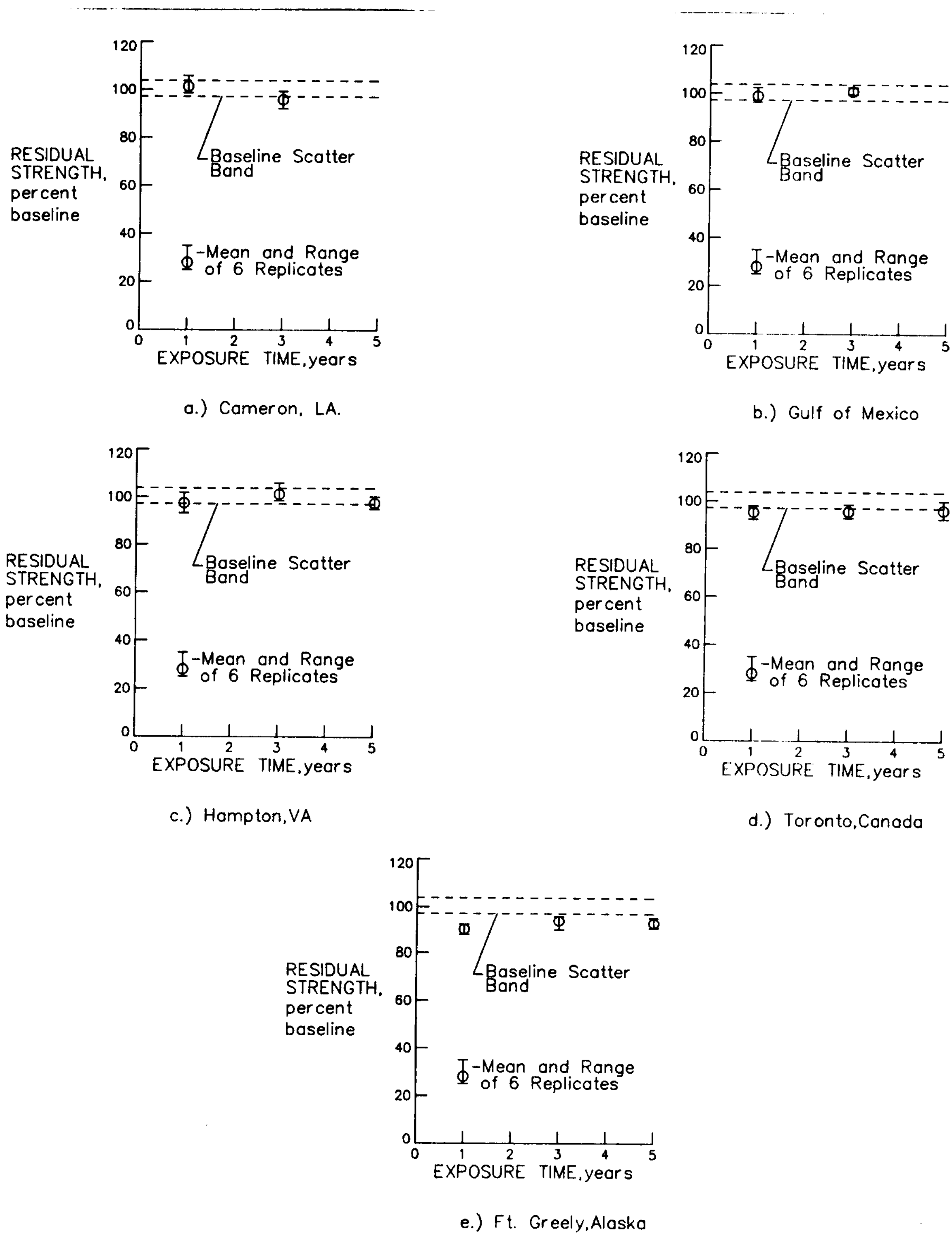
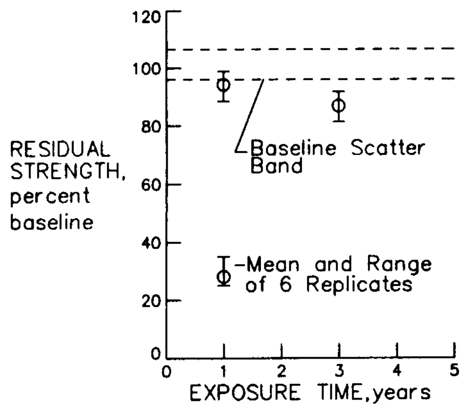
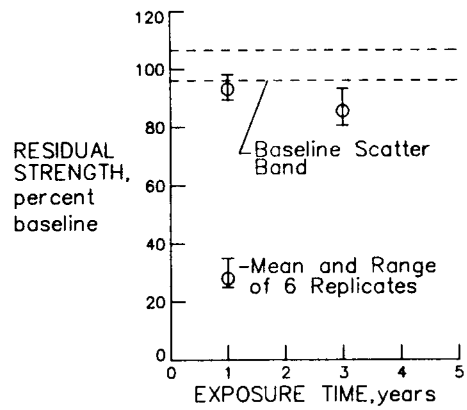


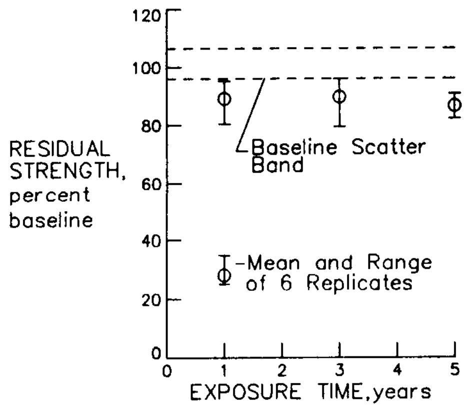
Figure 5 .-Residual Compressive Strength of Kevlar-49/F-185 Epoxy Specimens Exposed at Locations Shown



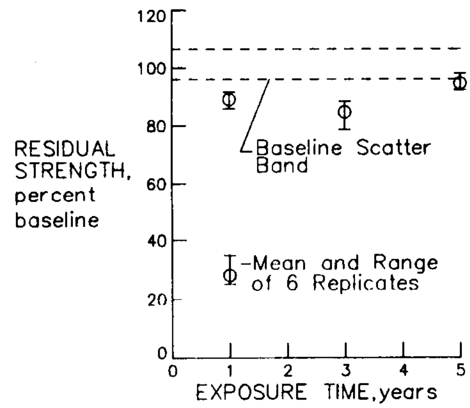
a.) Cameron, LA.



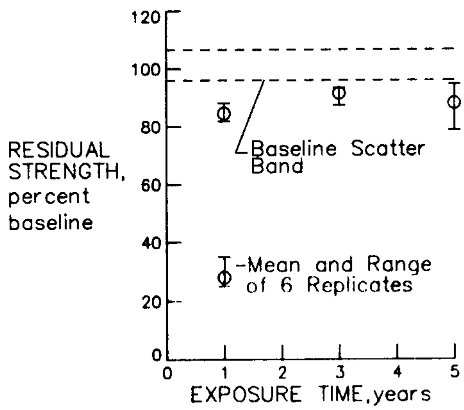
b.) Gulf of Mexico



c.) Hampton, VA

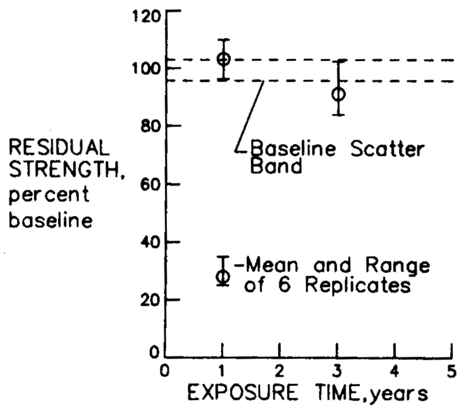


d.) Toronto, Canada

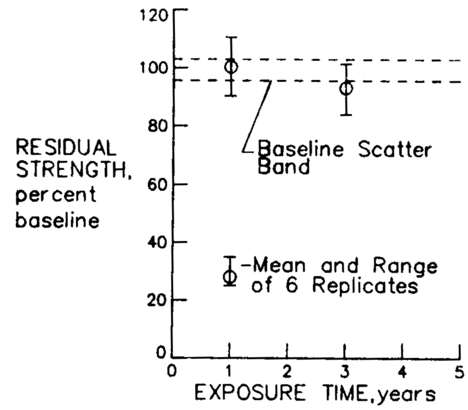


e.) Ft. Greely, Alaska

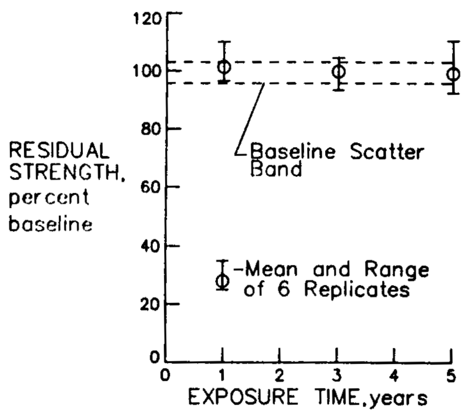
Figure 6 .-Residual Compressive Strength of Kevlar-49/LRF-277 Epoxy Specimens Exposed at Locations Shown



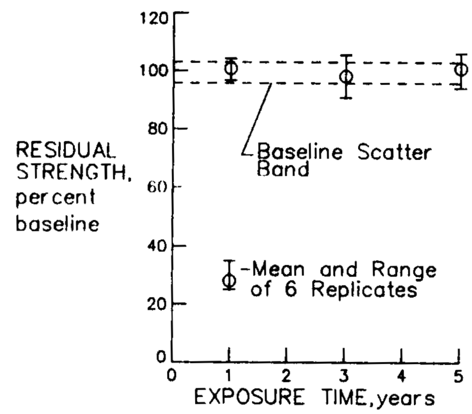
a.) Cameron, LA.



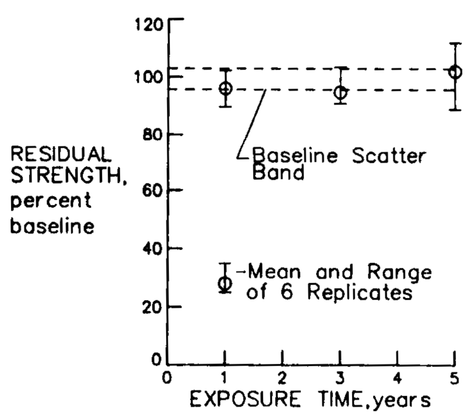
b.) Gulf of Mexico



c.) Hampton, VA



d.) Toronto, Canada



e.) Ft. Greely, Alaska

Figure 7.-Residual Compressive Strength of T-300 Graphite/E-788 Epoxy Specimens Exposed at Locations Shown

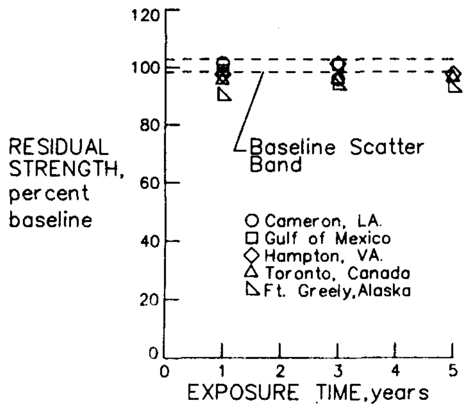


Figure 8 .-Effect of Exposure Location on the Residual Compression Strength of Kevlar-49/F-185

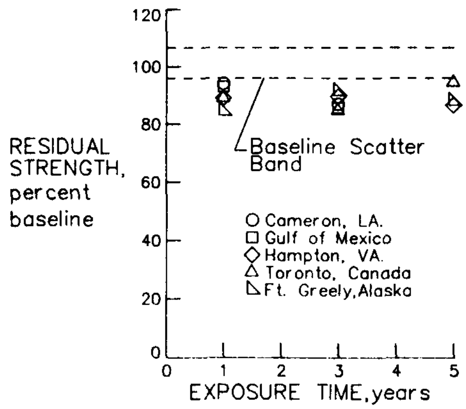


Figure 9 .-Effect of Exposure Location on the Residual Compression Strength of Kevlar-49/LRF-277

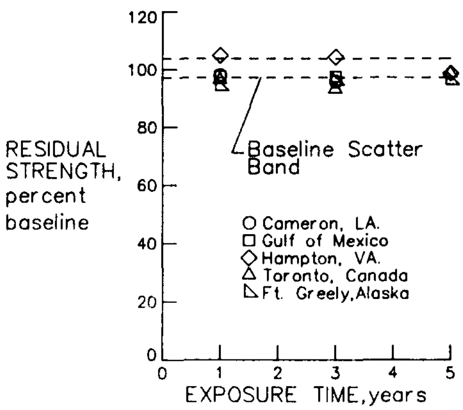


Figure 10 .-Effect of Exposure Location on the Residual Compression Strength of Kevalr-49/CE-306

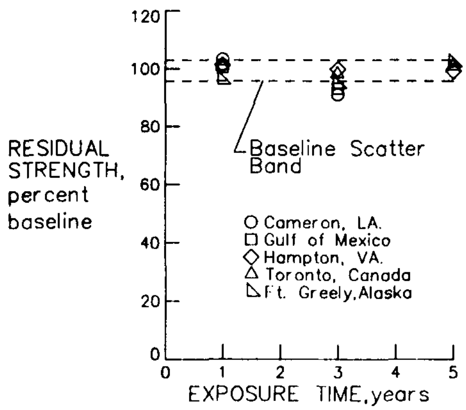


Figure 11 .-Effect of Exposure Location on the Residual Compression Strength of T-300/E-788

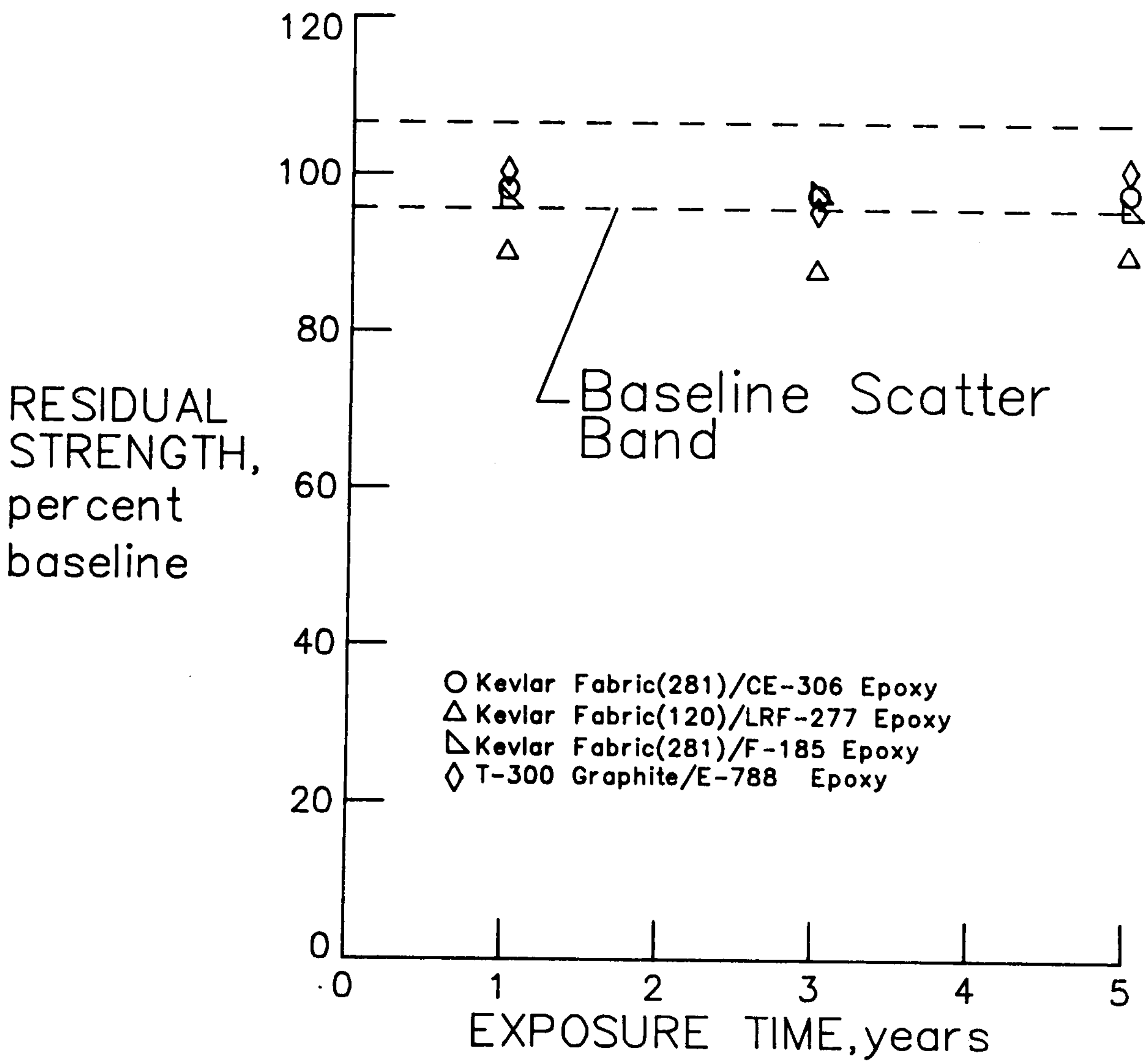


Figure 12.–Residual Compressive Strength of Composite Materials after Exposure

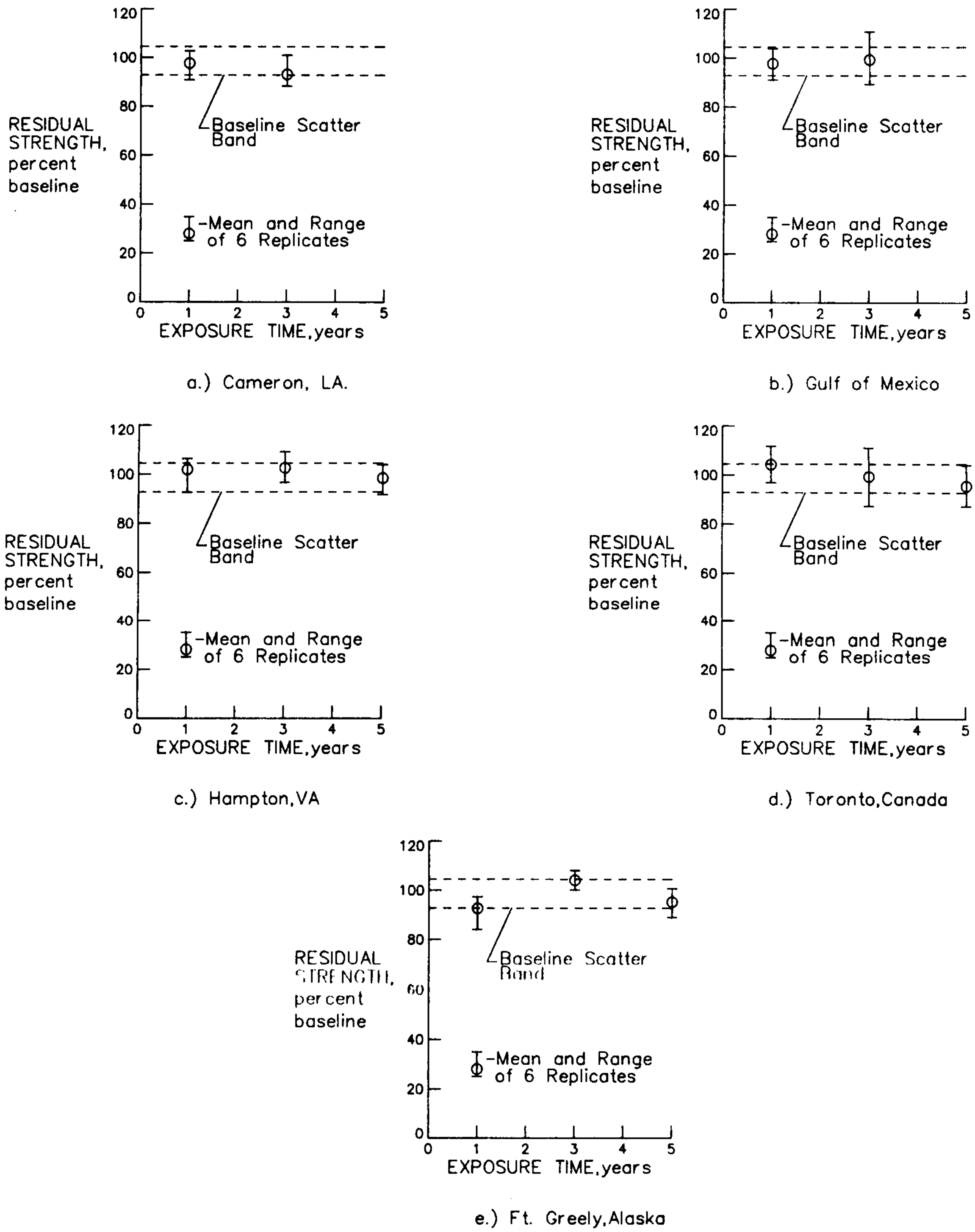


Figure 13.-Residual Short Beam Shear Strength of Kevlar-49/CE-306 Epoxy Specimens Exposed at Locations Shown

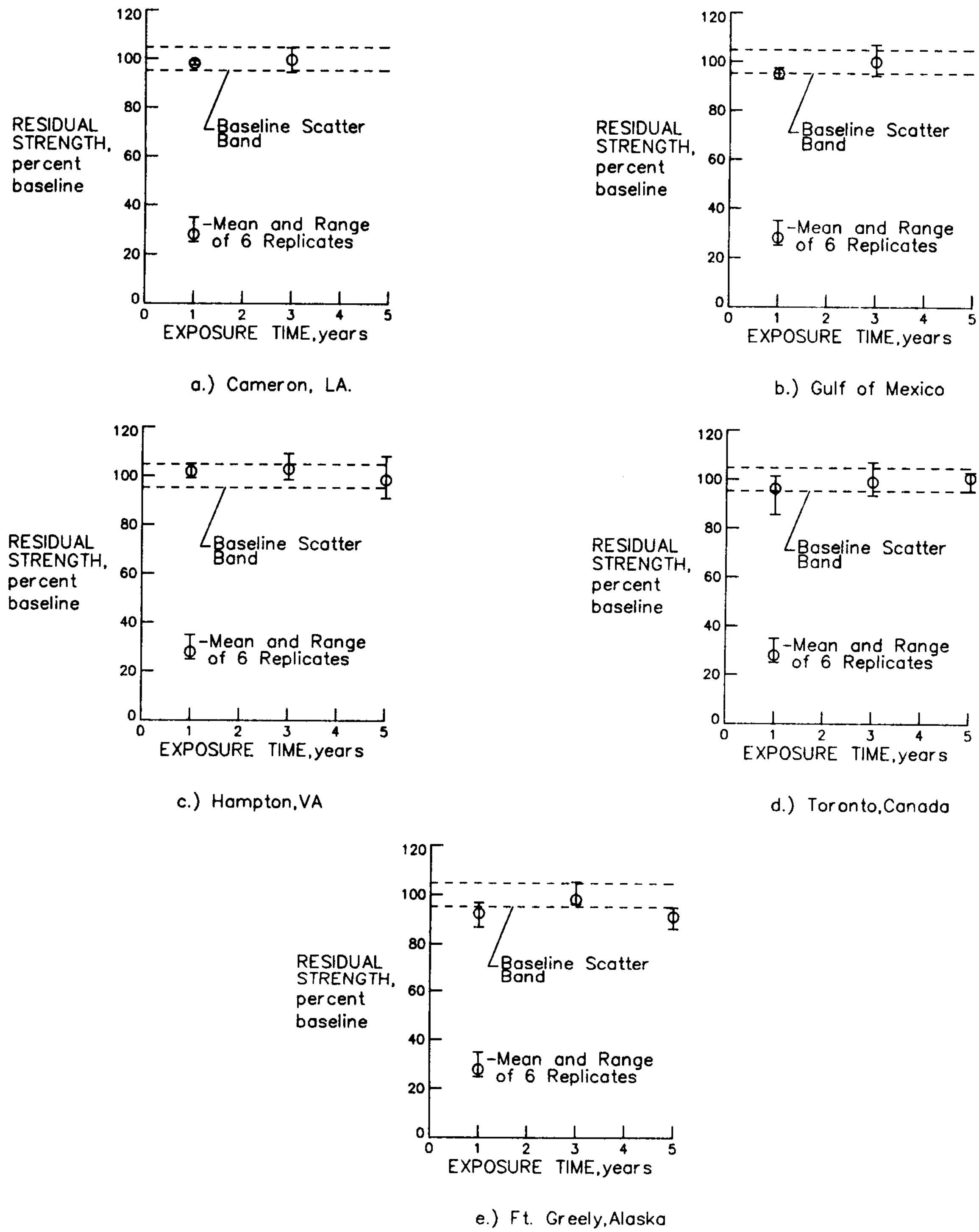


Figure 14.–Residual Short Beam Shear Strength of Kevlar-49/F-185 Epoxy Specimens Exposed at Locations Shown

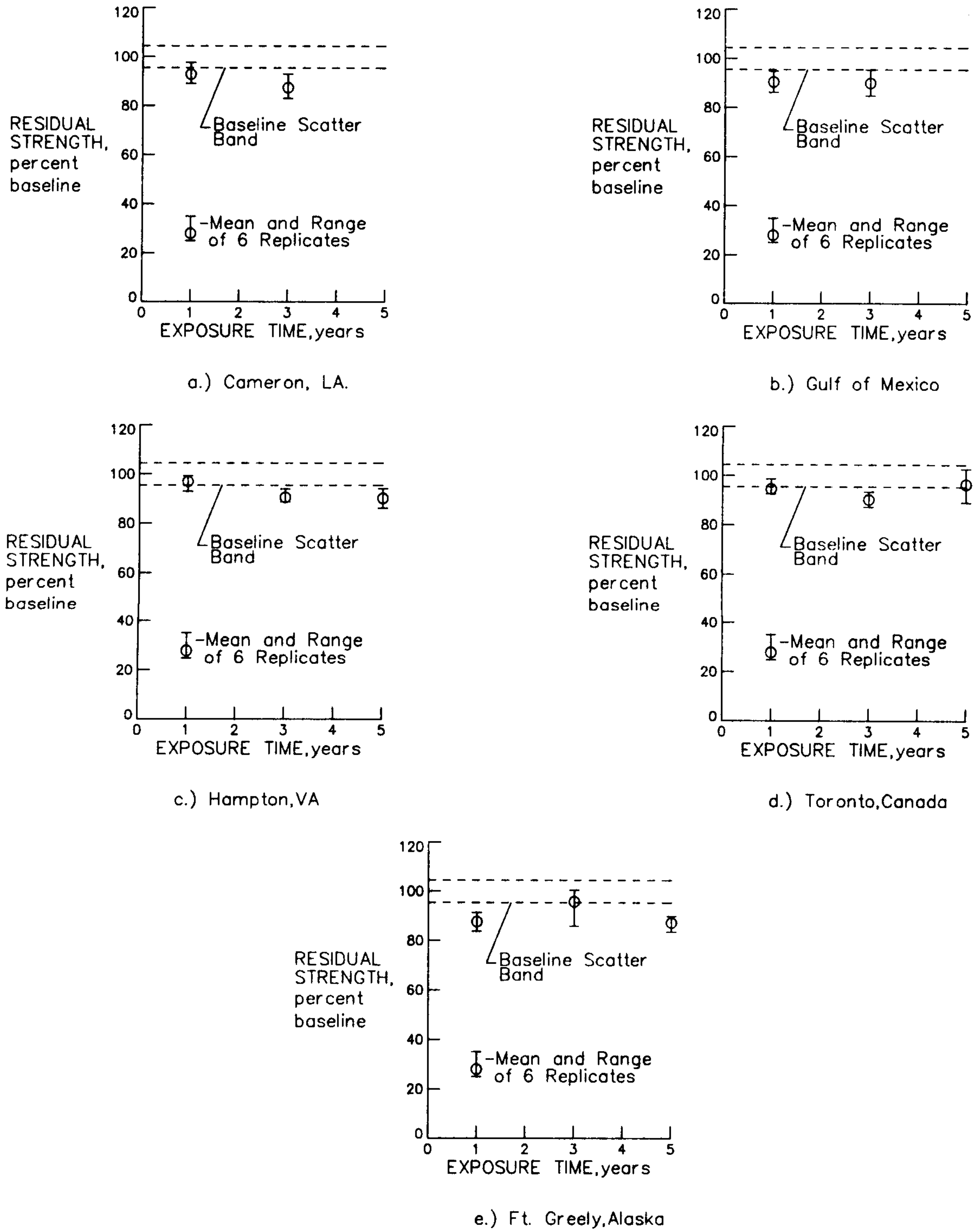


Figure 15.-Residual Short Beam Shear Strength of Kevlar-49/LRF-277 Epoxy Specimens Exposed at Locations Shown

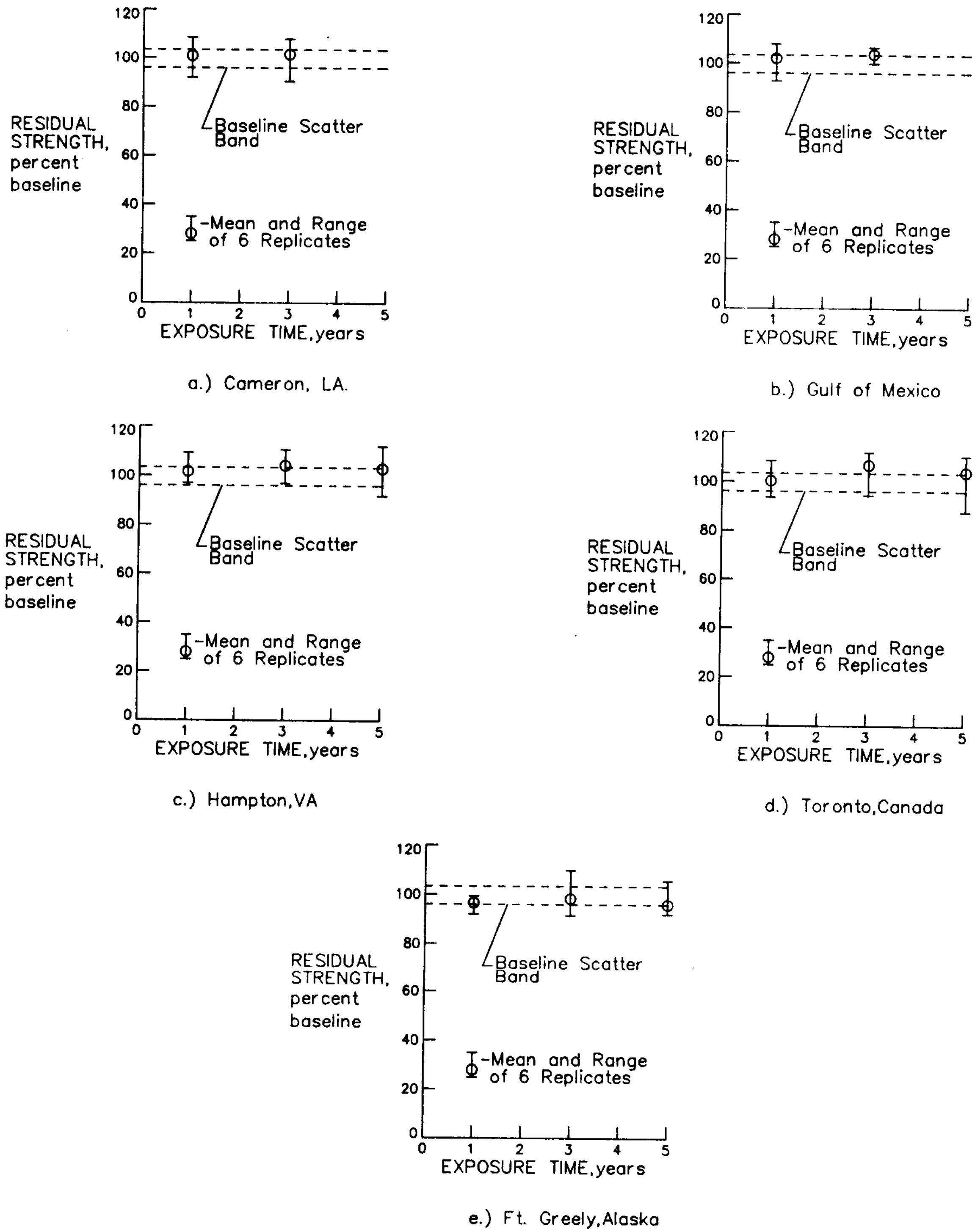


Figure 16.-Residual Short Beam Shear Strength of T-300 Graphite/E-788 Epoxy Specimens Exposed at Locations Shown

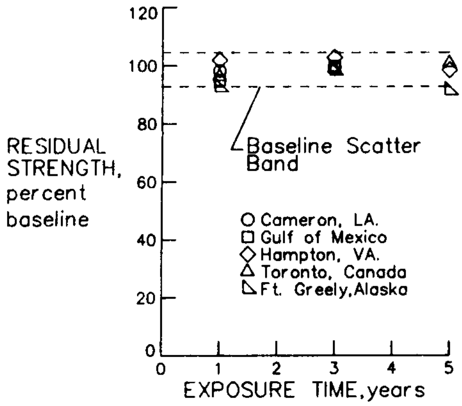


Figure 17.-Effect of Exposure Location on the Residual Short Beam Shear Strength of Kevlar-49/F-185

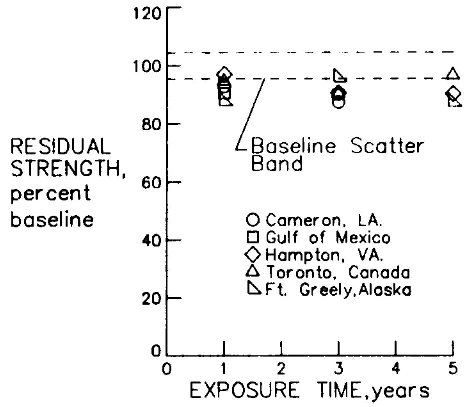


Figure 18.-Effect of Exposure Location on the Residual Short Beam Shear Strength of Kevlar-49/LRF-277

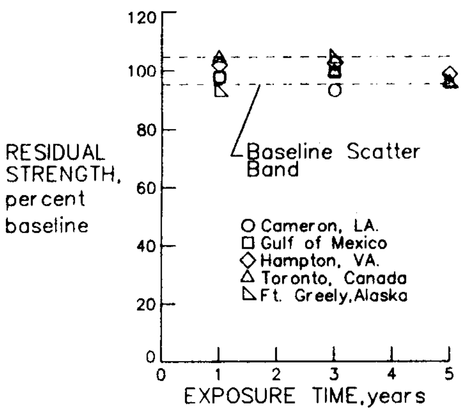


Figure 19.-Effect of Exposure Location on the Residual Short Beam Shear Strength of Kevalr-49/CE-306

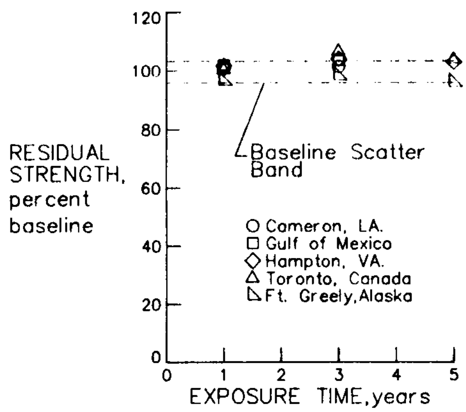


Figure 20.-Effect of Exposure Location on the Residual Short Beam Shear Strength of T-300/E-788

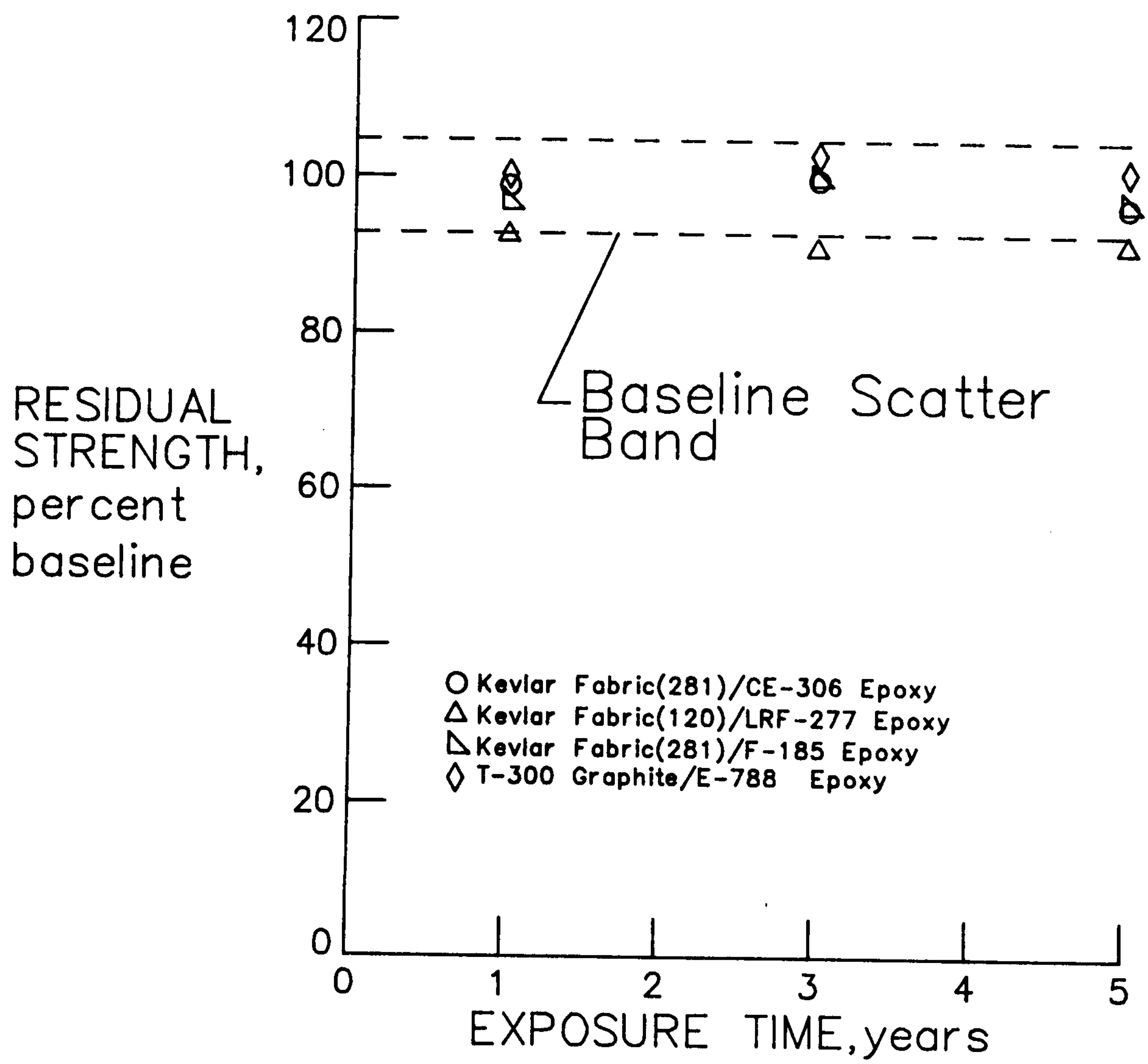


Figure 21.-Residual Short Beam Shear Strength of Composite Materials after Exposure

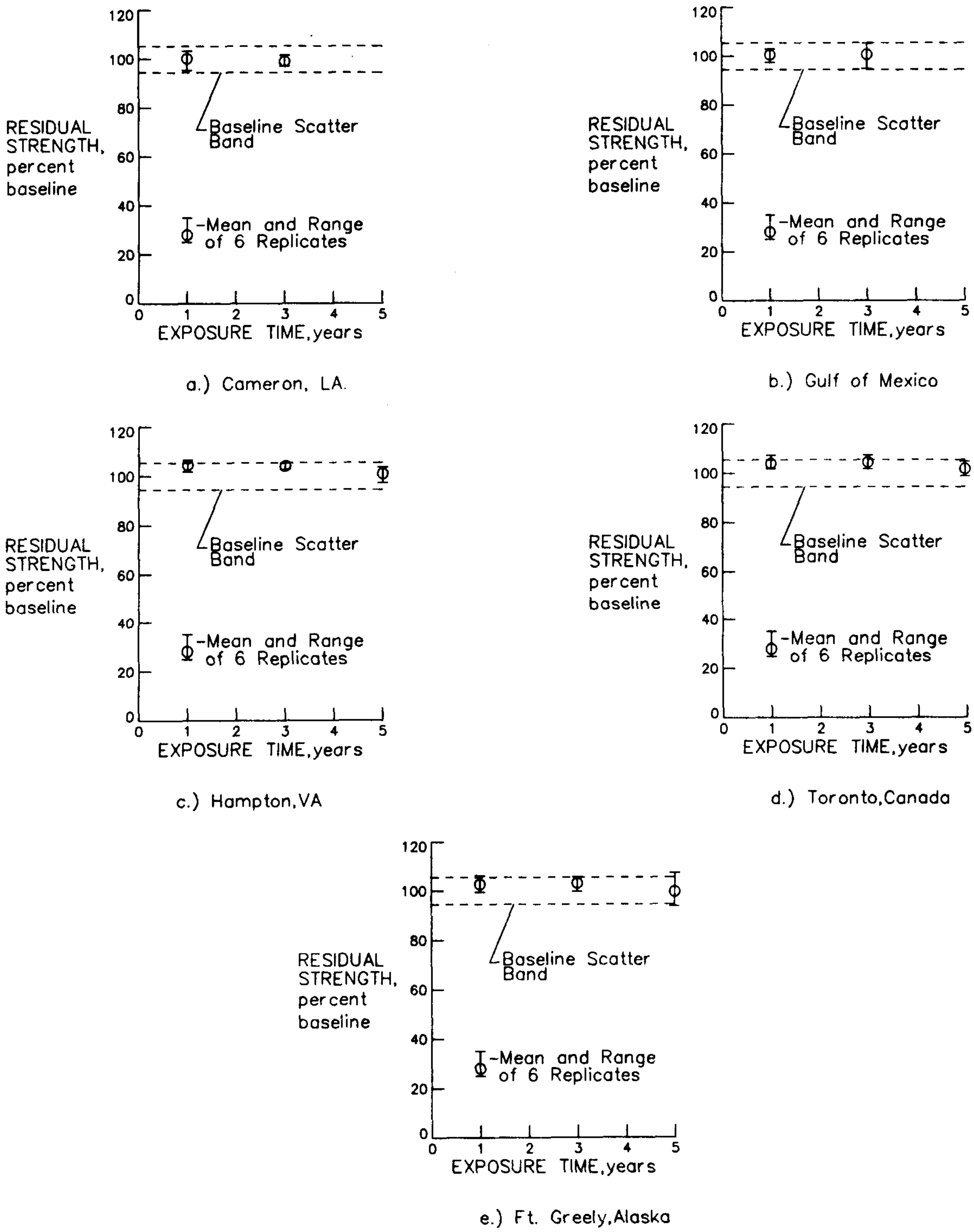


Figure 22.-Residual Tensile Strength of Kevlar-49/CE-306 Epoxy Specimens Exposed at Locations Shown

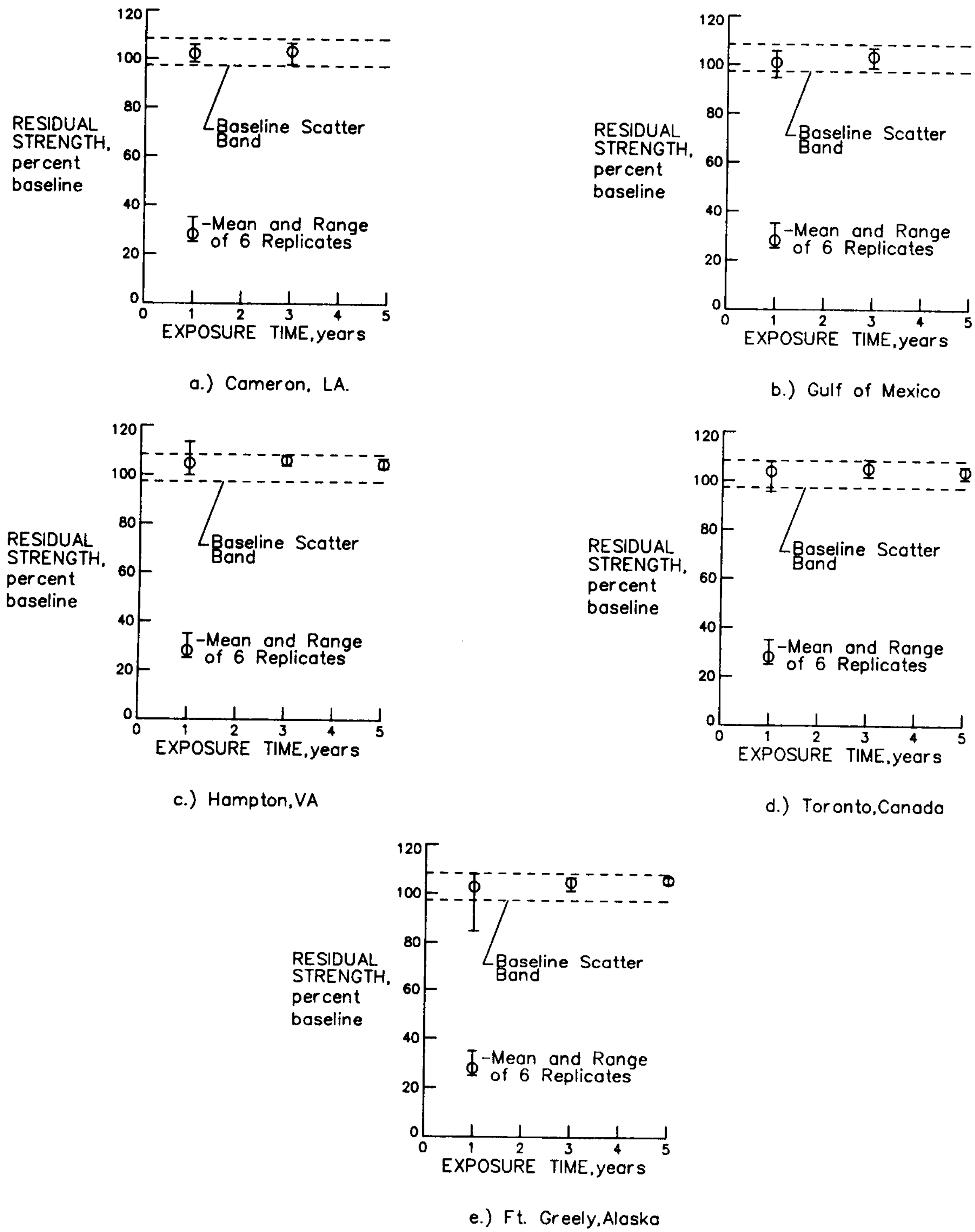


Figure 23.-Residual Tensile Strength of Kevlar-49/F-185 Epoxy Specimens Exposed at Locations Shown

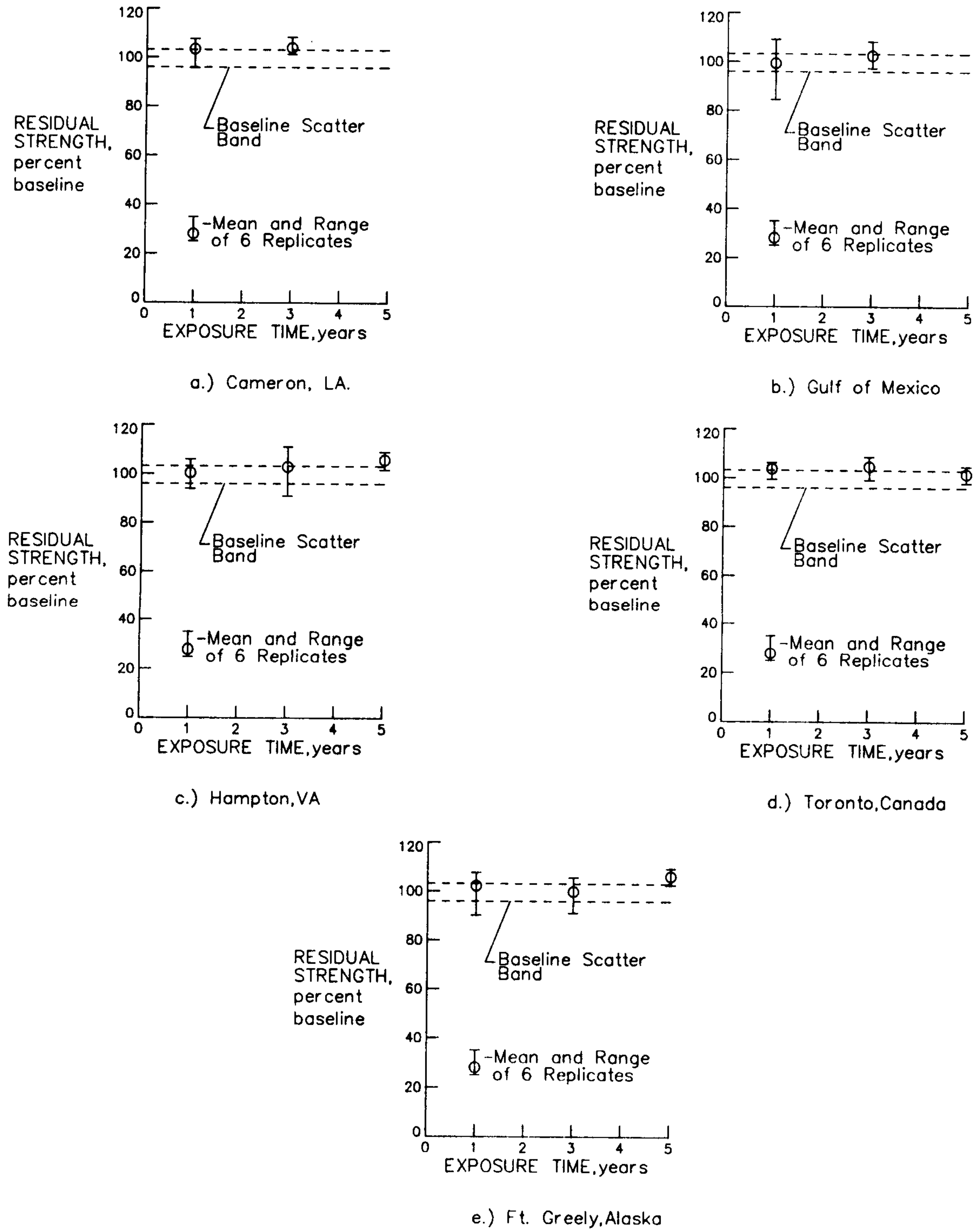


Figure 24.-Residual Tensile Strength of Kevlar-49/LRF-277 Epoxy Specimens Exposed at Locations Shown

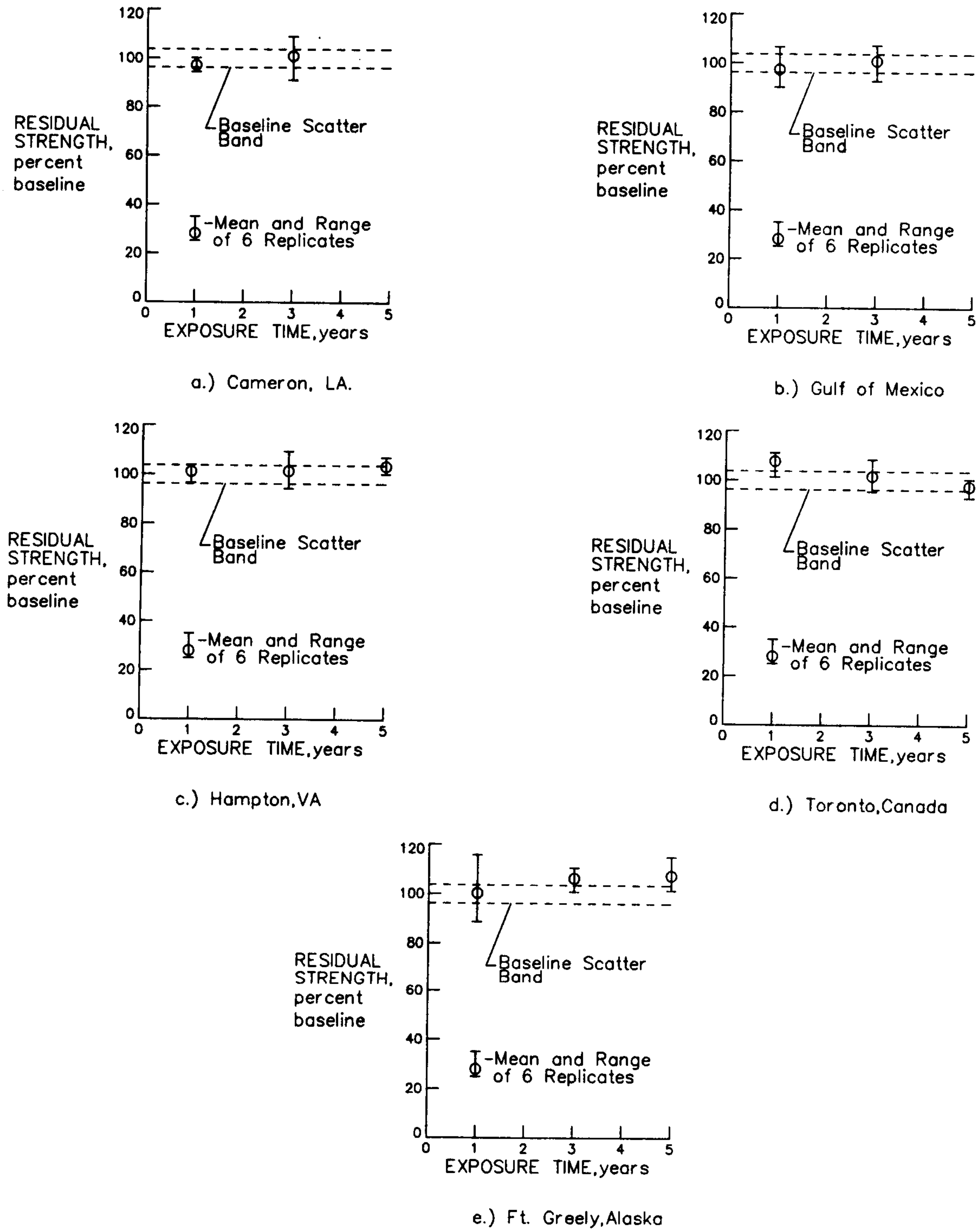


Figure 25.-Residual Tensile Strength of T-300 Graphite/E-788 Epoxy Specimens Exposed at Locations Shown

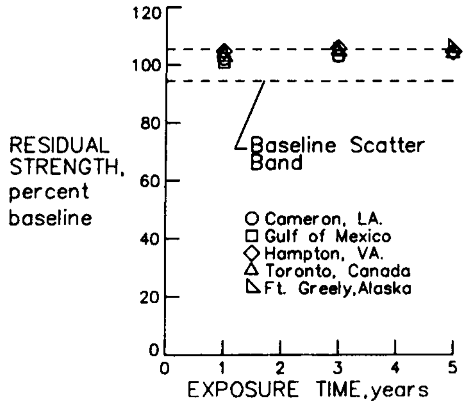


Figure 26.-Effect of Exposure Location on the Residual Tension Strength of Kevlar-49/F-185

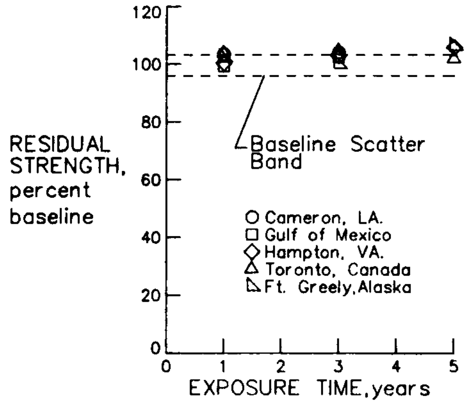


Figure 27.-Effect of Exposure Location on the Residual Tension Strength of Kevlar-49/LRF-277

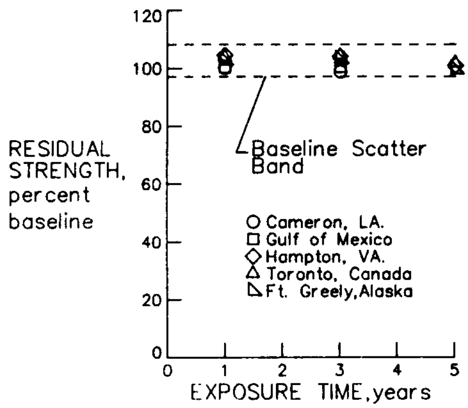


Figure 28.-Effect of Exposure Location on the Residual Tension Strength of Kevalr-49/CE-306

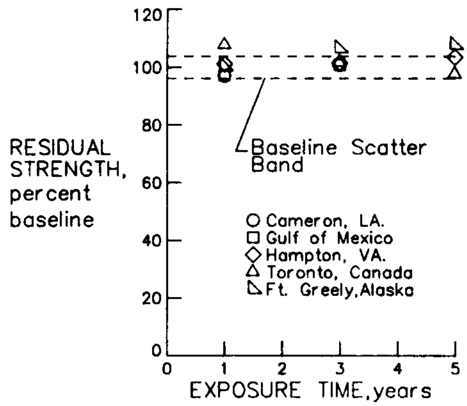


Figure 29.-Effect of Exposure Location on the Residual Tension Strength of T-300/E-788

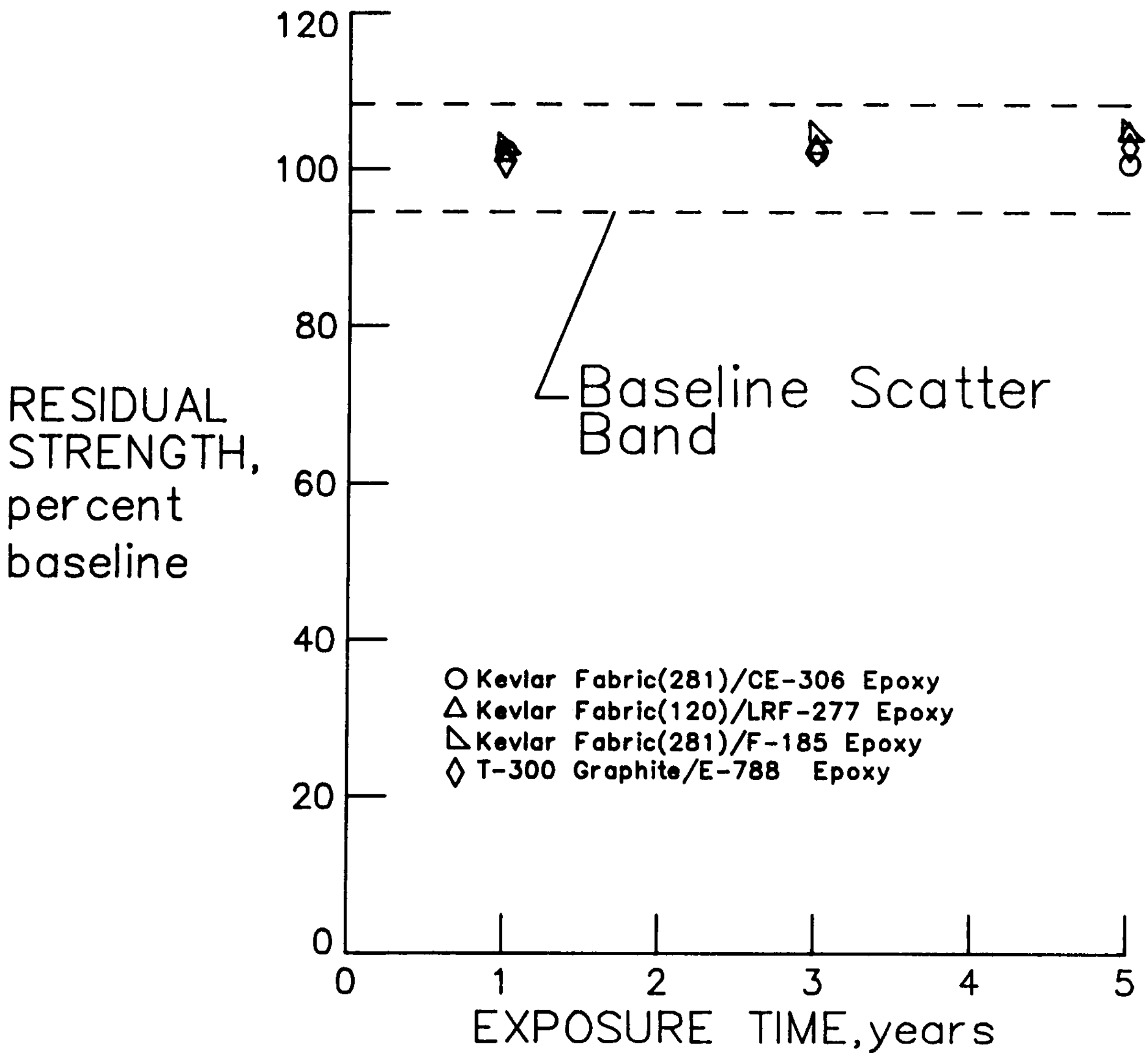


Figure 30.-Residual Tensile Strength of Composite Materials after Exposure

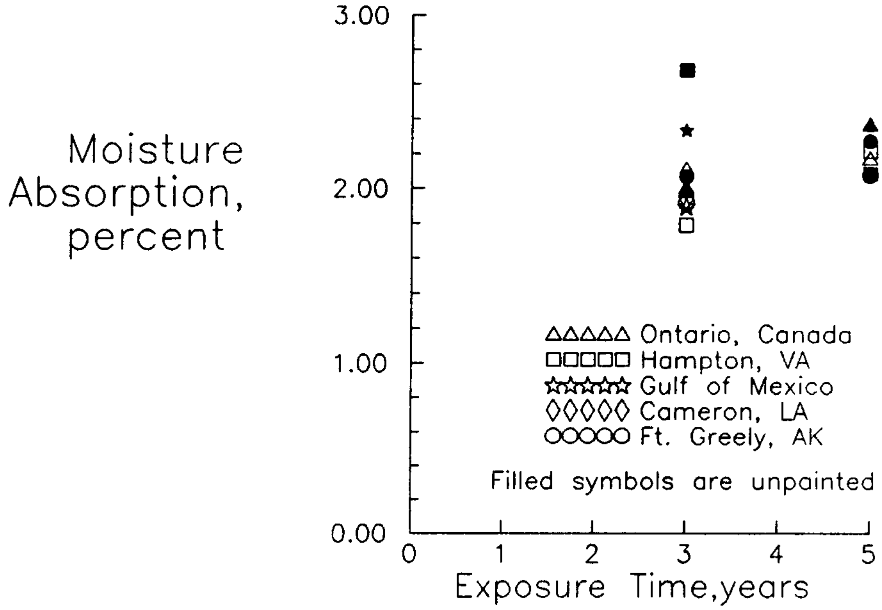


Figure 33. – Moisture absorption of Kevlar–49/LRF–277 Composite Material

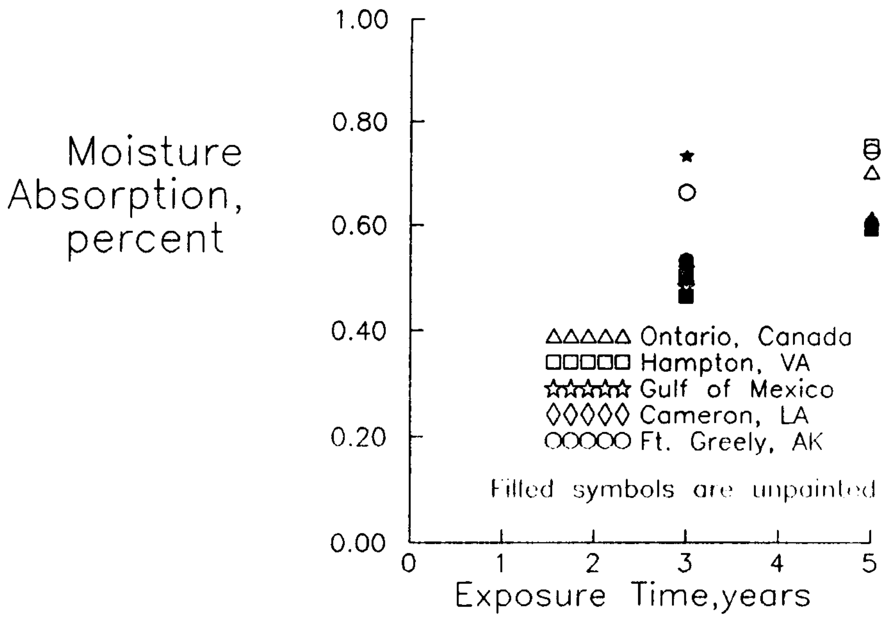


Figure 34. – Moisture absorption of T–300/E–788 Graphite/epoxy Composite Material

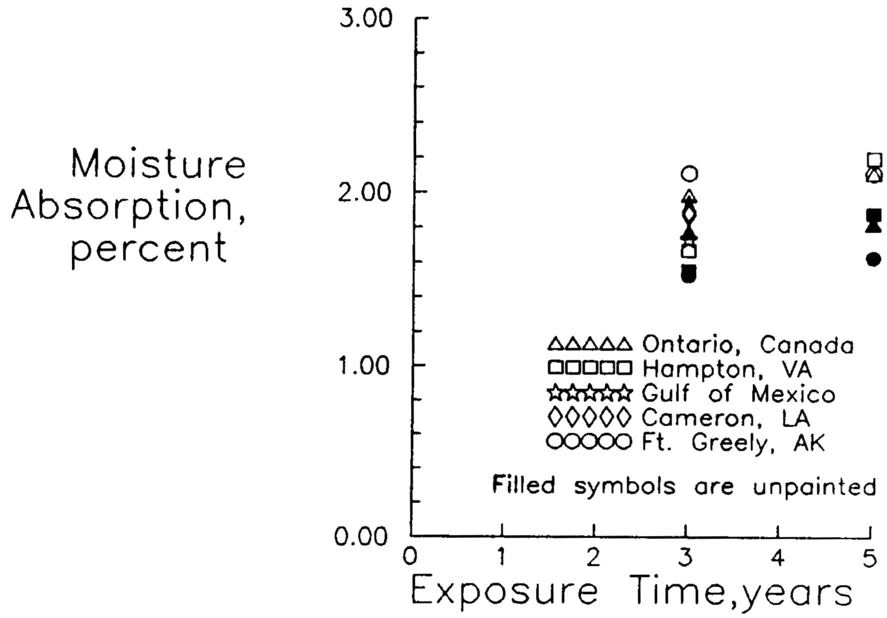


Figure 31. – Moisture absorption of Kevlar–49/CE–306 Composite Material

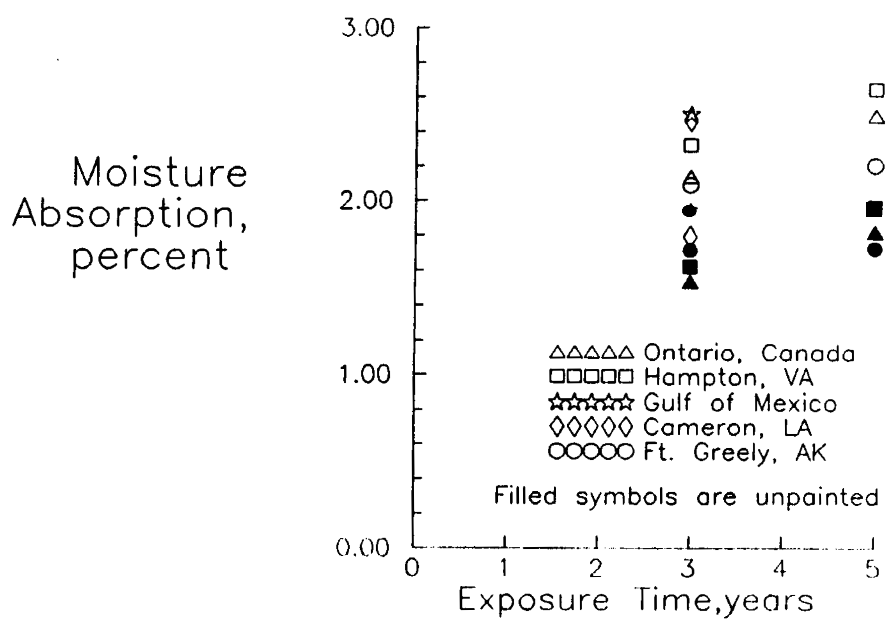


Figure 32. – Moisture absorption of Kevlar–49/F–185 Composite Material

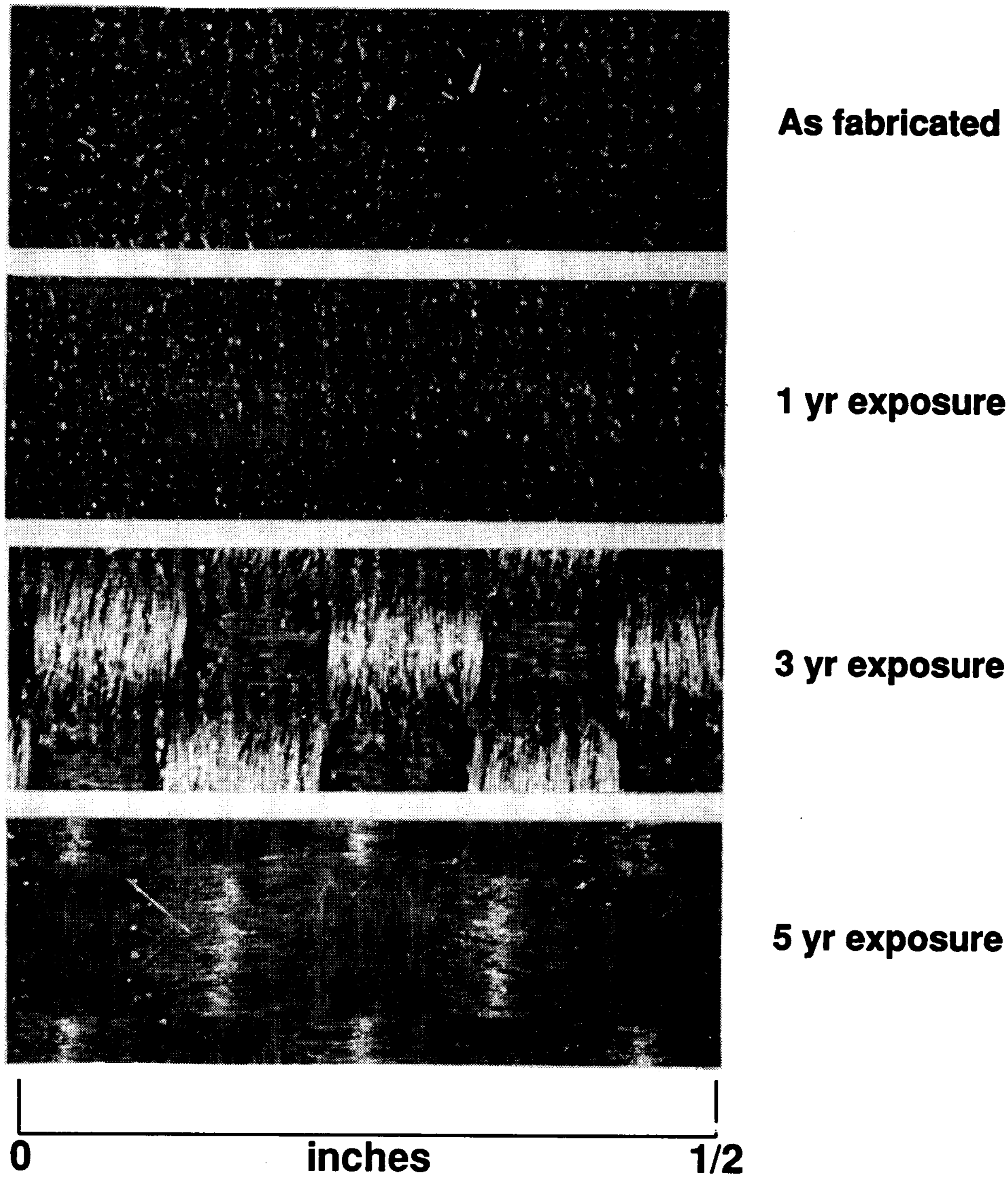


Figure 35. - Effects of Outdoor Exposure on Unpainted Kevlar-49/CE-306 Composite Material Exposed at Hampton, Va

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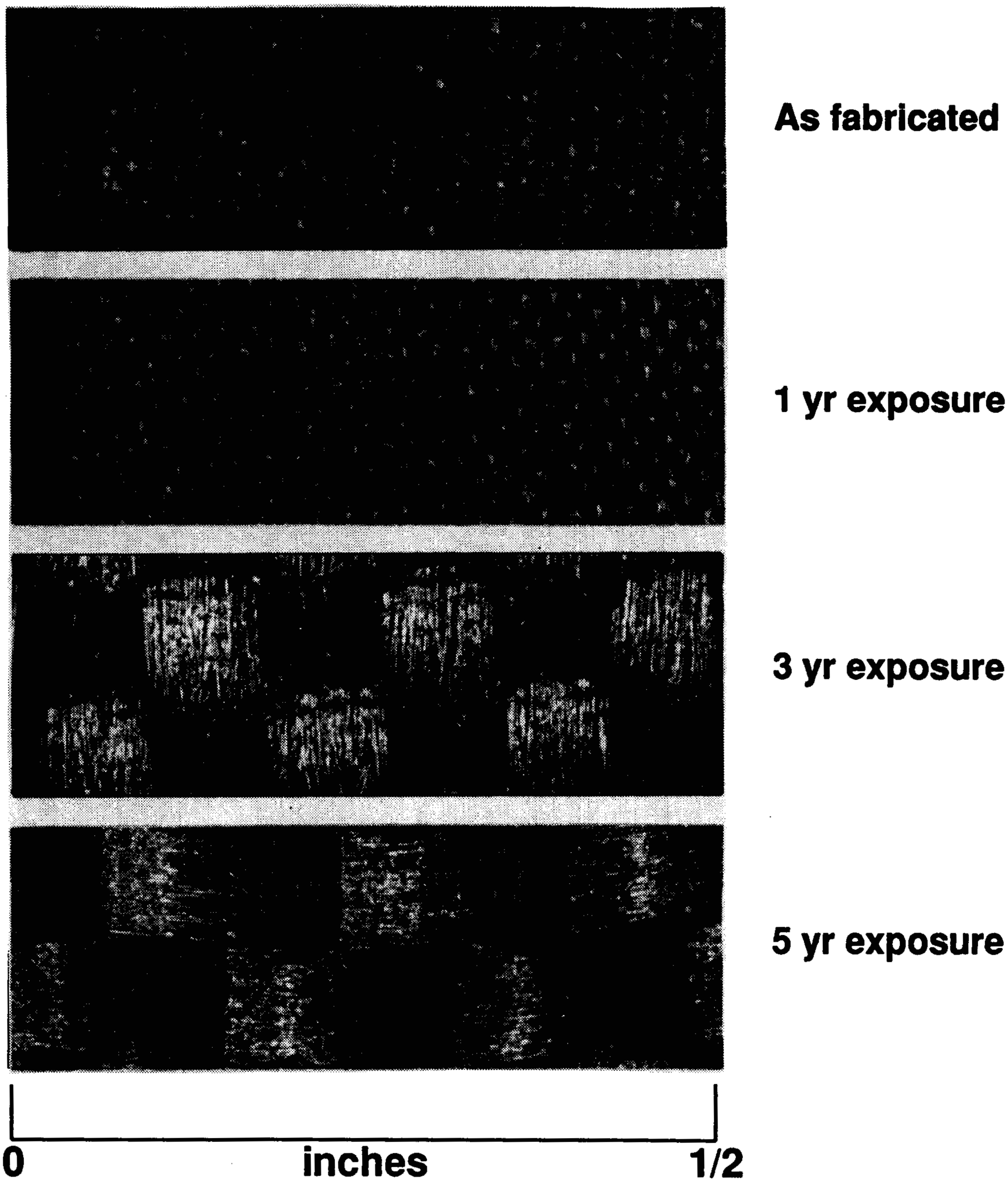

Figure 36. - Effects of Outdoor Exposure on Unpainted Kevlar-49/F-185 Composite Material Exposed at Hampton, Va

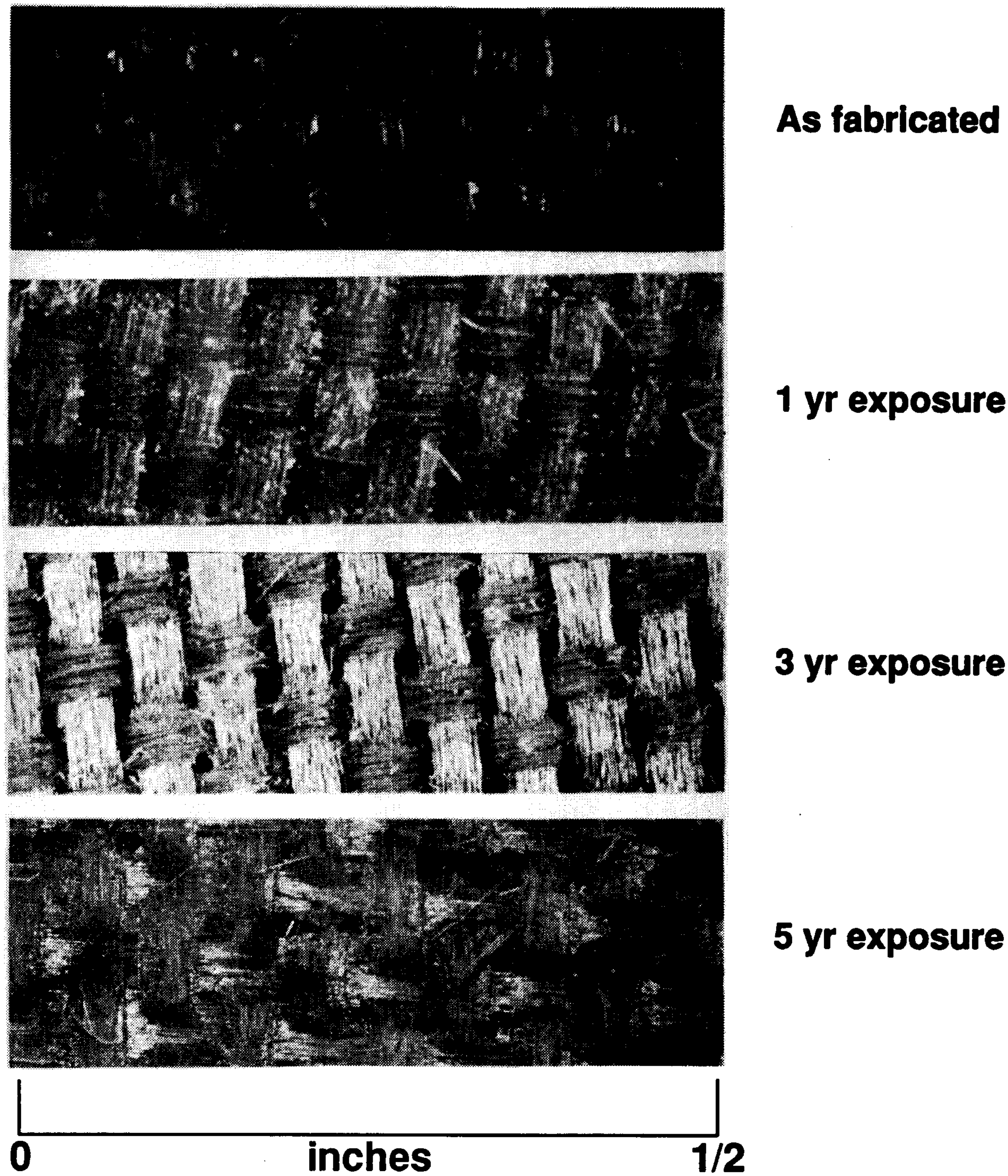

Figure 37. - Effects of Outdoor Exposure on Unpainted Kevlar-49/LRF-277 Composite Material Exposed at Hampton, Va

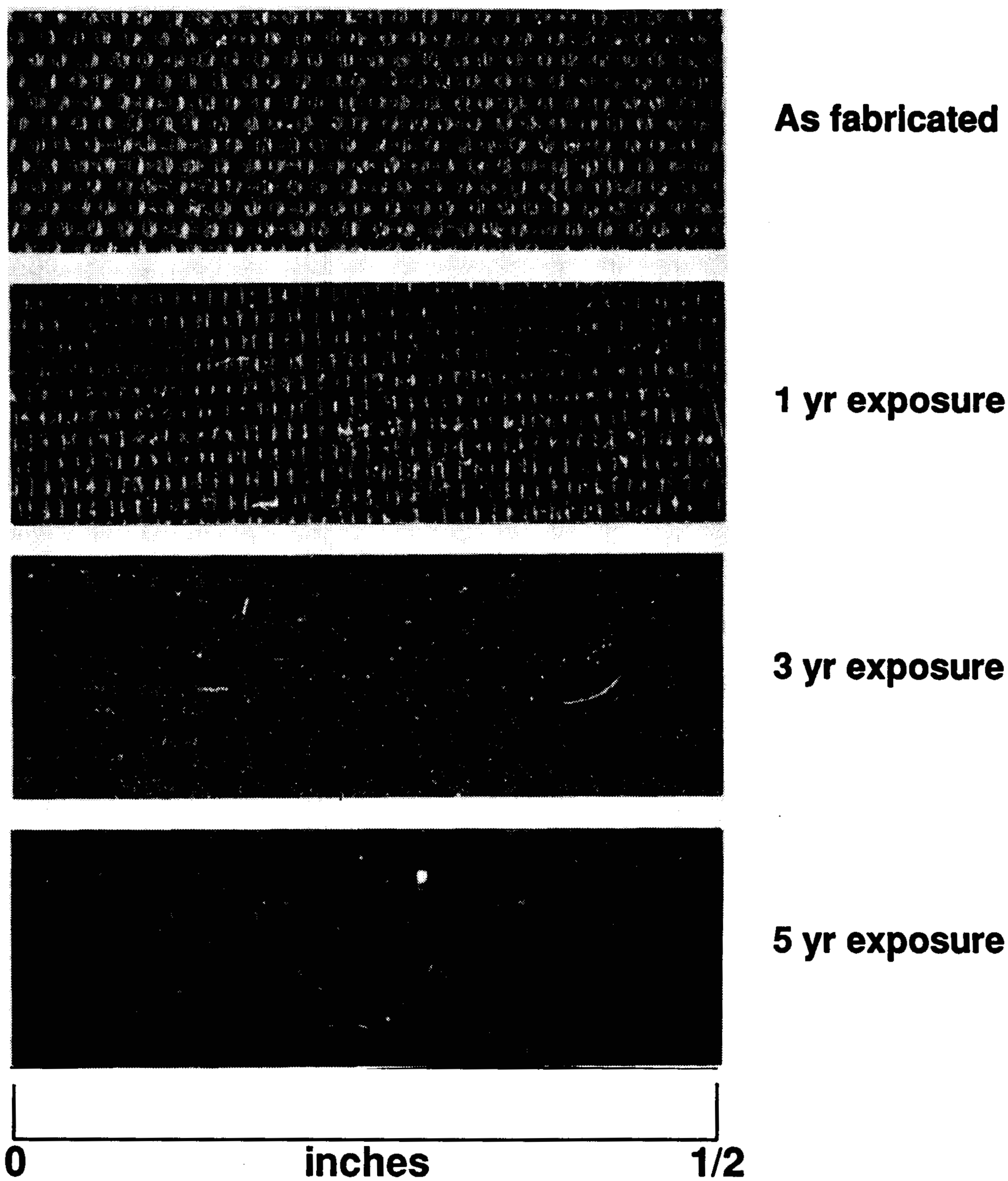

Figure 38. - Effects of Outdoor Exposure on Unpainted T300/E-788 Graphite/epoxy Composite Material Exposed at Hampton, Va

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16. Abstract

This report presents part of the results of a U.S. Army/NASA-Langley sponsored research program to establish the long term-term effects of realistic ground based exposure on advanced composite materials. Residual strengths and moisture absorption as a function of exposure time and exposure location are reported for four different composite material systems that have been exposed for five years on the North American Continent.

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